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PT 365

SCIENCE & TECHNOLOGY

Classroom Study Material (April 2023 to December 2023)

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2025, 2026 & 2027

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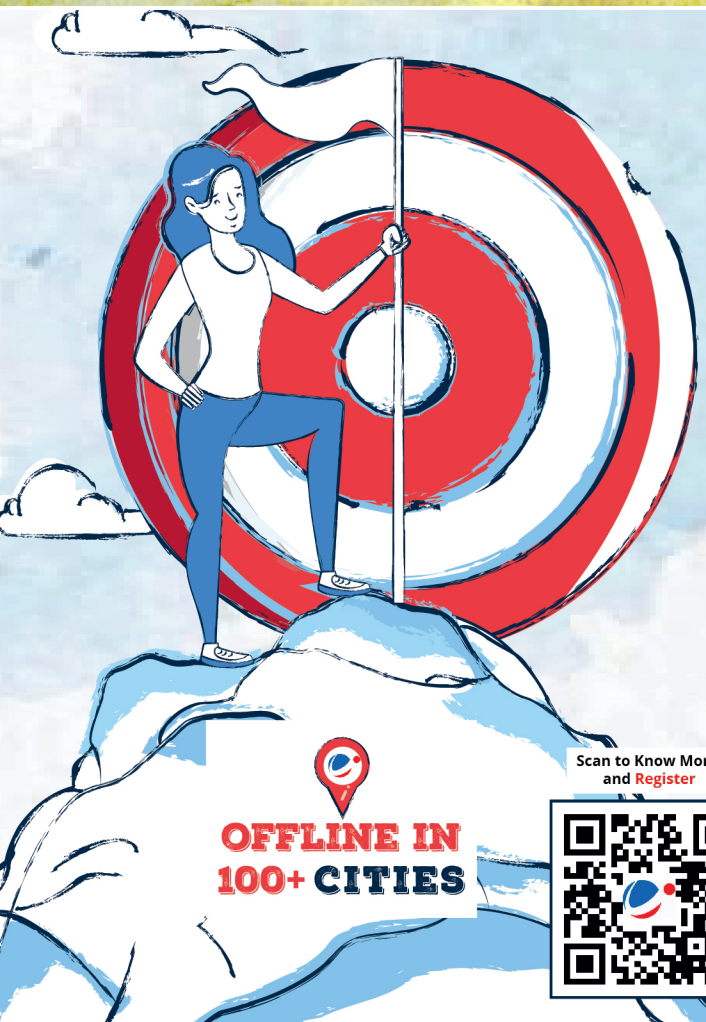
27 MAR	7 MAR	12 MAR	15 MAR



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SCIENCE AND TECHNOLOGY

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QUIZ

SMART QUIZ

You can scan this QR code to practice the smart quiz at our open test online platform for testing your understanding and recalling of the concepts.

Dear Students,

PT 365 document comprehensively covers the important current affairs of the last 1 year (365 days) in a consolidated manner to aid Prelims preparation. In our endeavour to further enhance the document in the interest of the aspirants, the following additions have been incorporated:

1. **Summarised infographics:** Topics such as:

   Key Application:
   With the help of the infographics applications of different technologies/ methods have been provided in crisp manner as has been repeated been asked in UPSC Prelims examination.

   Working of Technologies:
   The working of various techniques is presented through interactive infographics.

2. **Terminologies:** Special attention has been given to explaining key concepts from science to enhance the clarity of articles.

3. **Comparison/Differences Box**: Comparison between different techniques/methods/ concepts has been provided for holistic understanding.

4. **Appendix:** In Appendix important space missions and associated information of the **India Space Research Organisation (ISRO), National Aeronautics and Space Administration (NASA)** and other agencies have been added in a comprehensive way to facilitate quick revision.

5. **Crisp Points:** Endeavour has been made to present information in a crisp language so that it is easy to revise and retain.

6. **Quiz:** QR-based Smart Quiz will test your knowledge and ensure a more engaging and effective learning process.

1. BIOTECHNOLOGY

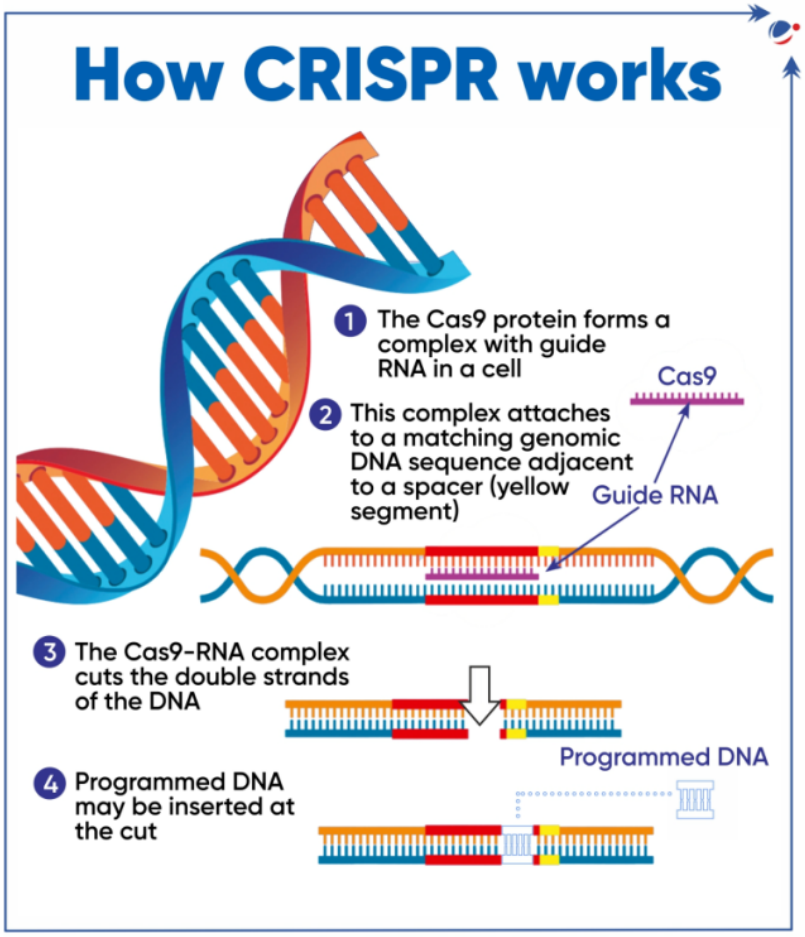
1.1. GENOME EDITING

Why in the News?

Indian researchers developed the first ever low-pungent mustard based on **Genome Editing (GE).**

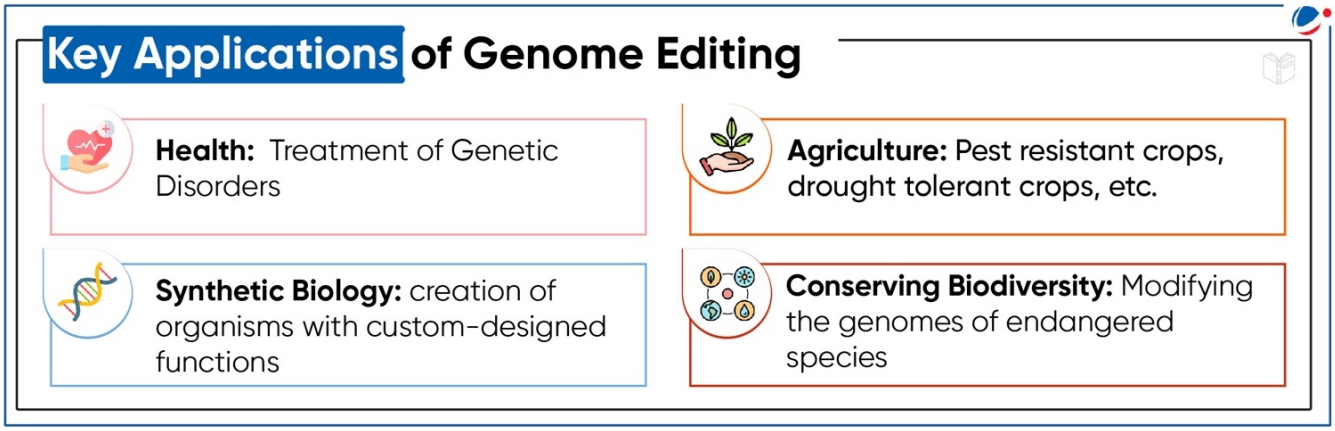
More about News

- New mustard variety is **less pungent as it has lesser quantity of glucosinolate** at par with the Canola quality limit (30 parts per million or PPM dry weight).
  - **High glucosinolates** causes goiter and internal organ abnormalities in livestock
- It is produced through **gene editing of 'Varuna'**, a high-yielding Indian mustard variety, using **CRISPR/Cas9 gene editing technology.**
- It protects **plants from invading pathogens, animals, etc.**
- **Indian mustard (Brassica juncea)** contains 120-130 ppm of glucosinolates.



About Genome Editing (GE)

- A type of method of altering **the DNA** of **organisms** (including plants, bacteria, and animals).
  - **Editing DNA** can lead to changes in **physical traits, like eye color,** and mitigate disease risk**.**
- Uses site directed nucleases (SDNs) to make changes that may either be a **small deletion, a substitution or the addition of a number of nucleotides**.
  - SDN refers to the **practice of cleaving DNA strands to effect the subsequent genome editing.**
  - Depending upon the nature of edit, this process is divided into three categories **SDN 1, SDN 2 and SDN 3.**
    - ✓ **Both SDN1 and SDN 2 do not involve alien genetic** material and the end result is indistinguishable from conventionally bred crop varieties.
    - ✓ On the other hand, **SDN3 process involves genes of foreign origin.**
- One of the application used is **CRISPR (Clustered Regularly Interspaced Short Palindromic Repeats)** technology (refer infographic)**.**
  - Other Genome Editing Techniques include: **zinc finger nucleases (ZFNs) and transcription activator-like effector nucleases (TALENs).**
- Unlike **Genetically modified organisms (GMO's)**, Gene Editing incorporates modification of existing genetic material to improve the quality.
  - **GMO** have **transgene (foreign genes)** for improvement in quality.
  - GM crops **require environmental clearance** from the **Genetic Engineering Appraisal Committee** (established under Environmental Protection Act 1986) of the Ministry of Environment, Forest, and Climate Change**.**



Related Development & Concepts

GM crops

- **GM crops carry genes of other species** artificially inserted into them.
- **Bt (Bacillus thuringiensis) Cotton**
  - A **Genetically Modified Crop or Transgenic crop.**
  - Contains **isolated genes from the soil bacterium Bacillus thuringiensis (Bt)** and coding for proteins toxic to **bollworm insect pests**.
  - Bt cotton is the **only GM crop that has been approved for commercial cultivation in India**.
  - However, it is said to **lost its** efficacy against the **Pink Bollworm (PBW) pest.**
  - Recently, GEAC asked states to test a new kind of transgenic cotton seed that contains a gene, **Cry2Ai**, which makes cotton resistant to pink bollworm.
  - Bollgard I and Bollgard II technologies have been used in Bt Cotton.
- In 2012, **Bt Brinjal** was also tried to introduce but it had **negative impact on health and environment.**
- **GM Mustard Dhara Mustard Hybrid-11 (DMH-11)** has been also been developed by Delhi University containing two alien genes isolated from a **soil bacterium called Bacillus amyloliquefaciens.**
  - DMH-11 is a result of a cross between two varieties: **Varuna and Early Heera-2.**
  - DMH-11 is a **transgenic crop because it uses foreign genes** from different species.

Enzyme Replacement Therapy (ERT)

- **U.S. Food and Drug Administration (USFDA) recently gave nod to world's first enzyme replacement therapy (ERT).**
  - It approved **Adzynma, the first recombinant (genetically engineered) protein product** indicated for on-demand ERT.
  - It will be used for treating **congenital thrombotic thrombocytopenic purpura (cTTP)**, a rare blood clotting disorder.
- ERT refers to the **treatment where replacement enzymes** are given to patients who suffer from conditions resulting from **enzyme deficiencies** or **malfunction.**

Recombinant DNA technology

- **Allows genes to be transferred across different species** of plants; from animals to plants; and from microorganisms to higher organisms.

1.1.1. GENE-DRIVE TECHNOLOGY (GDT)

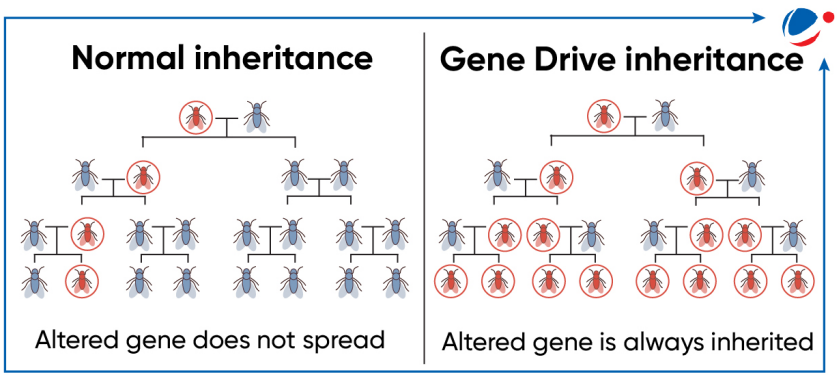
Why in the News?

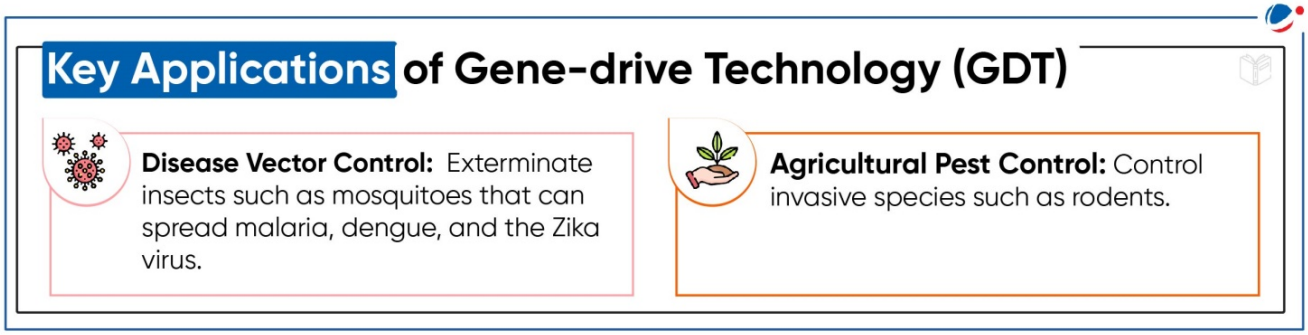
Applications based on Gene-drive Technology (GDT) have shown promising reductions in mosquito populations (by making them produce sterile offspring).

About Gene-drive Technology (GDT)

- A type of **genetic engineering technique** that modifies genes to alter **Mendelian inheritance (Normal)**.
  - **Mendelian inheritance** refers to certain patterns of how traits are passed from parents to offspring.

- **3 Key Components of Gene Drive:**
  - **Gene,**
  - **Cas9 enzyme** (acts as a **molecular scissor)** and
  - **CRISPR (Clustered Regularly Interspaced Short Palindromic Repeats) i.e.** repetitive DNA sequences.
- **Genetic material** that encodes for these three elements **gets inserted into an animal's DNA, in place of the naturally occurring gene**.
  - It increases the **likelihood that a particular suite of genes will be passed onto the next generation**.





1.1.2. GENOME SEQUENCING

Why in the News?

Scientists have successfully sequenced the Y-chromosome using 'long-read' genome sequencing techniques.

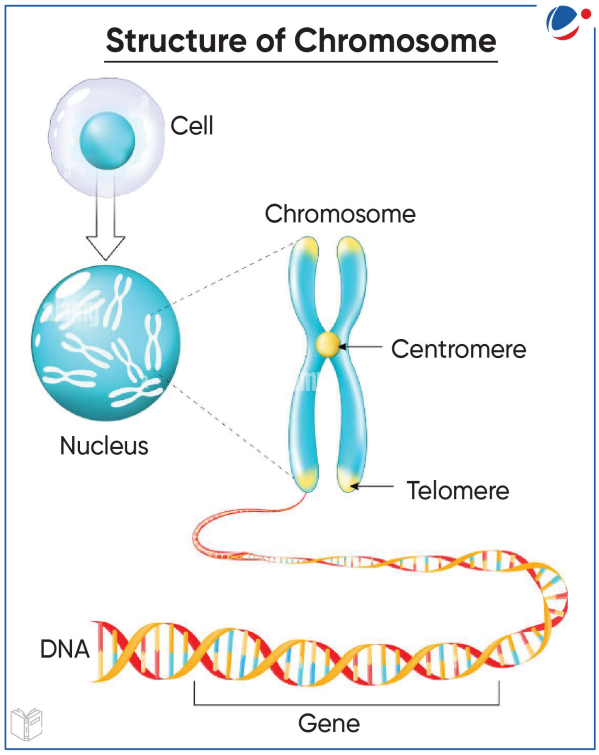
About Genome sequencing

- Method of **figuring out the order of DNA nucleotides, or bases,** in a genome i.e. the order of Adenine, Cytosine, Guanines, and Thymine that make up an organism's DNA.
  - A **genome** is an organism's complete set of DNA.
  - It includes all **chromosomes**, which houses DNA, and **genes** (specific sections of DNA).
- Apart from long read technique, **short read technique is also used for genome sequencing.**
  - **Short-read sequencing**: In this, genome is broken into small fragments (usually 50 to 300 bases) before being sequenced.
    - ✓ **More effective for applications aimed at counting the abundance of specific sequences**, profiling the expression of particular transcripts, etc.
  - **Long-read sequencing:** In this, DNA is fragmented and tagged for sequencing to keep track of each fragment, followed by local assembly.
    - ✓ **Provides sequences that are easier to distinguish** and can, therefore, be assembled more easily, handling the confusing repetitions and loops of the Y chromosome.
- **Aerial metagenomics'** (direct genetic analysis of genomes) involves the study of the genetic composition of microbial samples collected from air.

About Chromosomes

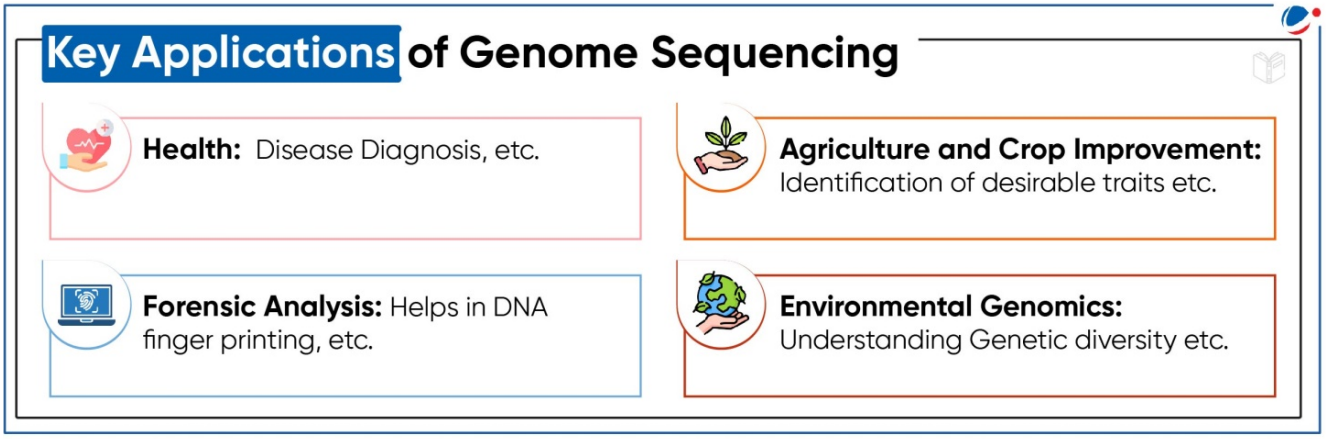
- Chromosomes are **thread-like structures** made of protein and a single molecule of DNA carry the **genomic information from cell to cell.**
  - In plants and animals, **resides in the nucleus of cells**.
  - Humans have **22 pairs of numbered chromosomes** (autosomes) and **one pair of sex chromosomes** (XX or XY), for a **total of 46 (23 pairs)**.

- **About Y-chromosome**
  - **Y chromosome is last human chromosome to be sequenced** end-to-end (**telomere-to-telomere (T2T)).**
    - ✓ **Telomeres** (made from DNA sequences and proteins) **cap and protect** the **end of a chromosome.**
  - **Male-determining** because it bears **SRY genes (sex-determining region Y).**
  - Has a lot of '**junk DNA** (sequences don't contribute to traits)'.
  - **Individuals** having **Y chromosome** are related to a single Y-bearing ancestor as it is passed down from **male parent to male offspring.**



Comparison between Y – and X– Chromosome

- Y is always contributed by sperms (X by eggs or sperms)
- Y is smaller than X (Contains just around 100 protein coding genes)
- Y occurs single in male only
- Y represents 2% of entire human genome (X represents 5%)



Key initiatives for Human Genome sequencing

- **Human Genome Project,** launched in 1990 (completed in 2003), covered about 92% of the total human genome sequence.
- **In 2022, Telomere to Telomere (T2T) consortium** sequenced the entire human genome (100%).
- **Genome India Project (GIP): an initiative of the Department of Biotechnology (DBT),** aims to collect 10,000 genetic samples from citizens across India, to build a reference genome.
  - Recently, DBT **announced completion of sequencing 10,000 Human Genome.**
- **IndiGen programme:** CSIR initiated it in April 2019 in which **whole genome sequencing of 1029 self-declared healthy Indians** drawn from across the country has been completed.

1.2. THREE PARENT BABY

Why in the news?

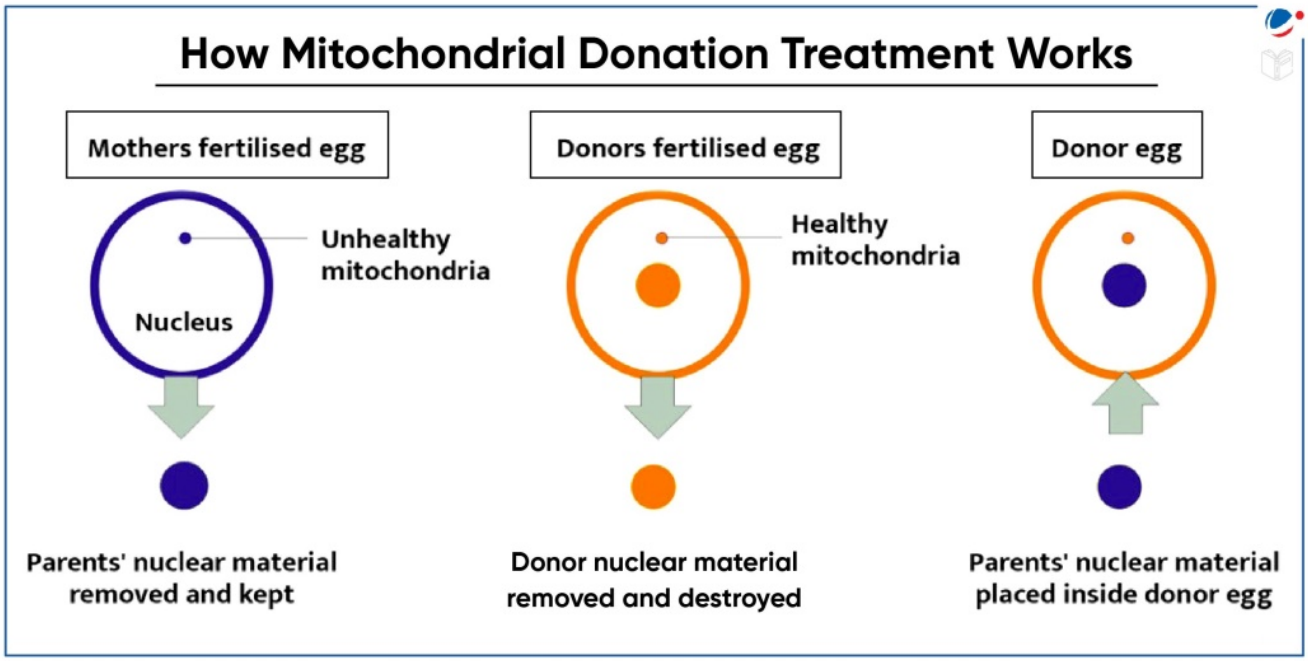
A baby has been born using three people's DNA in the UK with help of **Mitochondrial Donation Treatment (MDT)** procedure.

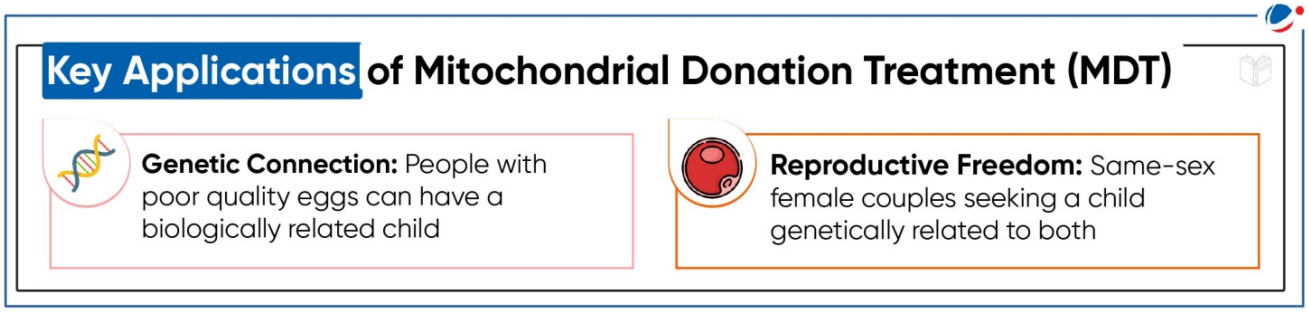
About Mitochondria

- **Powerhouses of the cells.**
- **Generate the energy** for **cell.**
- **Mitochondrial DNA** comes only from the **mother.**

About MDT

- **Involves conceiving a child from IVF (in vitro fertilization)** using the genetic material of the parents and the **mitochondrial material of a donor.**
- **Diseased mitochondria are replaced by healthy mitochondria** in order to avoid transfer of mitochondrial diseases from the mother to the offspring.
  - Done **either before or after IVF** of **the egg.**
- Also known as **Mitochondrial Replacement Therapy (MRT)** and **Three-parent babies process**.
  - Latter name is used due to involvement of three persons.
- **Mechanism: Embryo** from the **biological parents** is combined with **mitochondria** from the donor's egg. (refer infographic)
- **Most common techniques:** Maternal Spindle Transfer (MST) Technique and Pronuclear Transfer (PNT) technique (substitute to MST).
  - In both techniques, eggs or embryos are created using nuclear genetic material and healthy donated mitochondria.





Related Development
Cell-free DNA (cfDNA)

- Refers to **small fragments of nucleic acids** that are released from **cells and found outside the cell in body fluids** as plasma, urine, and cerebrospinal fluid (CSF).
- cfDNA quantity in the blood increases under pathological conditions such as auto-immune diseases, cancer etc.
- **Applications:**
  - **Detect genetic abnormalities** in foetuses,

- **Early detection,** diagnosis, and treatment **of cancers,**
- **Monitor immune response** after organ transplantation and **can be used as a biomarker.**

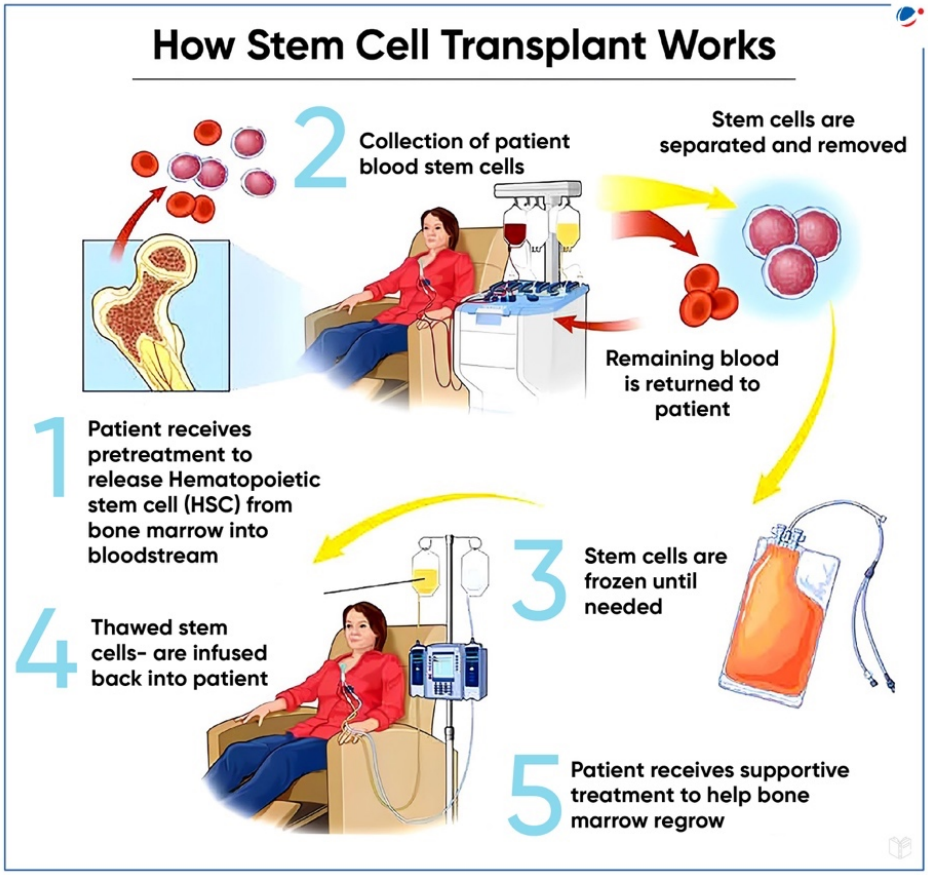
Molecular motor

- Researchers have discovered a new kind of molecular motor, also referred as motor protein.
- **Molecular motor** are remarkable molecular machines within a cell that converts chemical energy stored in a molecule called ATP, into mechanical work.

1.3. STEM CELLS

Why in the News?

A team of scientists have created the first synthetic human embryo-like structures in the world **using stem cells.**



About Discovery

- These synthetic embryos **resemble natural embryos** in the earliest stages of human development.
- They **lack a beating heart or the beginnings of a brain** but, they contain **cells** that would give rise to the **placenta, yolk sac** etc.
- **Benefits of Synthetic Embryo**
  - **Understanding** the impact of **genetic disorders**.
  - **Biological** reasons behind recurrent **miscarriages.**
  - **Genetic, epigenetic, and environmental effects** on a developing embryo.
  - Understanding the **"black box of human development"**, the period before a pregnancy's progress can be detected on a scan.

About Stem Cell

- A cell with the unique ability **to develop into specialised cell types in the body.**
- **Provide new cells for the body** as it grows, and replace specialised cells that are damaged or lost.
- **Two unique properties**:
  - Can divide over and over again to produce new cells.
  - As they divide, they can change into the other types of cell that make up the body.
- **Regenerative Medicine (RM) Research revolves around the use of stem cells**, like embryonic, adult, and induced pluripotent stem cells (iPS).
  - RM is the **process of replacing or "regenerating" human cells, tissues or organs to restore or establish normal function**.
- **Applications of Stem cells**
  - **Understanding** nature of **disease.**
  - **Stem cell therapy (SCT): Introducing new stem cells** into **damaged tissue.**

- ✓ It could be-
  - **Autologous transplantation** (uses the patient's own stem cells)
  - **Allogeneic transplantation** (uses stem cells from a donor).
- **Toxicology (drug side effects):** In clinical research to assess the impact of the drug.

- In India, **ICMR has released the National Guidelines for Stem Cell Research (NGSCR) 2017** for the ethical and scientific conduct of stem cell research through guidelines for stem cell research.

Categories of stem cells on the basis of capacity to give different types of cells

Totipotent	Pluripotent	Multipotent	Unipotent
Totipotent: Can make **all three embryonic germ layers** and the **extra-embryonic tissue. The only known** indisputably totipotent cell is the **zygote.**	**Pluripotent:** Can make **multiple lineages from all three embryonic germ layers** (ectoderm, mesoderm and endoderm). For example, **Embryonic stem cells (ESCs).**	**Multipotent:** Can **make at least two different lineages,** usually from the **same embryonic germ layer.** For example, **hematopoetic stem** cells give rise to different blood cells (White, Red and platelets) from the blood lineage.	**Unipotent:** Can produce **only one cell type but** have the property of self-renewal that distinguishes them from non-stem cells. Example, skin cell

NOTE: induced Pluripotent Stem cells (iPS cells) are made in the lab from **adult cells.**

Related Development
Chimera

- **World's first Live Birth of Chimeric Monkey** was reported in China with two sets of DNA.
- A **chimera is a single organism composed of cells** of more than one distinct genotype (or genetic makeup).
  - **Major types of chimera:**
    - ✓ **Natural**: Animal kingdom has several examples of varying degrees of chimerism, including humans.
      - For instance, the **traces of the foetus's genetic material** are **observed in mothers' tissues many years after childbirth (Micro-chimerism)**.
    - ✓ **Artificial**- It can be done through **stem cell transplant** or **bone marrow transplant**.

1.4. CAR-T CELL THERAPY

Why in the news?

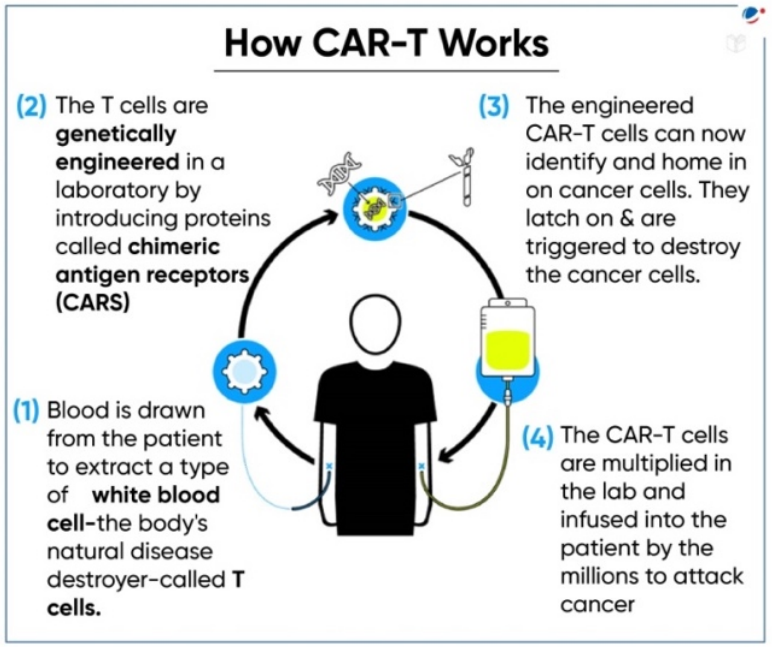
Recently, a cancer patient has been treated with the help of Indigenous NexCar19, a **Chimeric Antigen Receptor T cell (CAR-T cell) therapy.**

More about News

- Central Drugs Standard Control Organisation (CDSCO) has approved the Indigenous NexCar19, a CAR-T cell therapy.
- It is **developed indigenously in India by ImmunoACT** (company incubated at IIT Bombay).
- CDSCO is the **Central Drug Authority for discharging functions** assigned to Central Government under Drugs and Cosmetics Act 1940.
  - **Major functions**: Regulatory control over import of drugs, approval of new drugs and clinical trials etc.

CAR T cell Therapy

- Type of **cellular immunotherapy treatment** that **uses T cells** that are **genetically altered in a lab** to enable them in locating in destroying cancer cells more effectively.
- **T cells are immune cells** that **attack infection-causing pathogens** (viruses, bacteria, fungi and parasites) and harmful cells, like cancer cells.



About NexCAR19 (Actalycabtagene autoleucel)

- Designed to target cancer cells that carry the **CD19 protein**.
  - CD-19 is a biomarker (or flag) for **B lymphocytes (or B-cells)**.
    - ✓ A **Biomarker** provides information about a biological process, condition, or response to a treatment.
- Targets Leukaemia and **B-cell lymphomas** (blood cancer).
- Uses genetically modified patient's T cells to target cancer while chemotherapy uses drugs.
- **Advantages**:
  - High precision
  - Single or few infusion treatment
  - Individualized treatment
- **Challenges**:
  - Proliferation of CAR T-cells leads **Cytokine Release Syndrome (CRS).**
    - ✓ CRS means abundance release of **cytokines into the bloodstream** triggering an intensified immune system response.
    - ✓ **Cytokines** play an important role in normal immune responses, but excessive cytokine production causes an immune response that can damage organs, especially the lungs and kidneys, and even lead to death.
    - ✓ **A cytokine storm** can occur as a result of an infection, autoimmune condition, or other disease.
  - **Neurological Toxicity**

Related Concept
Lymphocytes

- Lymphocytes are a type of **White Blood Cells (WBCs)** and are **part of the immune system**.
- They are two main types of lymphocytes: **T cells and B cells.**
- **T-Cell directly fight with foreign invaders**
  - Also produce cytokines, activates other parts of the immune system.
- **B-Cell produces antibody molecules** that attack invading viruses or bacteria.
- **Both originate in** bone marrow.
- Former provide cell**-mediated immunity** and latter provide **humoral immunity** (immune responses directed at particular antigens)**.**

Related Development
Tissue Engineering

- CDSCO **approved first indigenously developed animal-derived tissue engineering scaffold** for healing skin wounds.
- Tissue Engineering is **a biomedical engineering discipline** that Creates **tissues or cellular products outside the body** or to **repair tissues within the body**.

- **Combines the principles of materials** and **cell transplantation** to develop substitute tissues and/or promote endogenous regeneration.
- **E.g. Artificial skin** and **cartilage**

Kill Switch for Cancer Cells

- Scientists have reportedly **discovered a 'kill switch'** that triggers death of cancer cells.
- Identified as a crucial epitope (a protein section that can activate the larger protein) **on the CD95 receptor that can cause cells to die**.
- **CD95 receptors- also referred to as Fas** - send a signal that causes cancer cells to self-destruct.
- **Future cancer drugs could boost the activity of these CD95 receptors** to create a new weapon against cancer tumors,
- **Cancer have been treated historically** with **surgery, chemotherapy and radiation.**

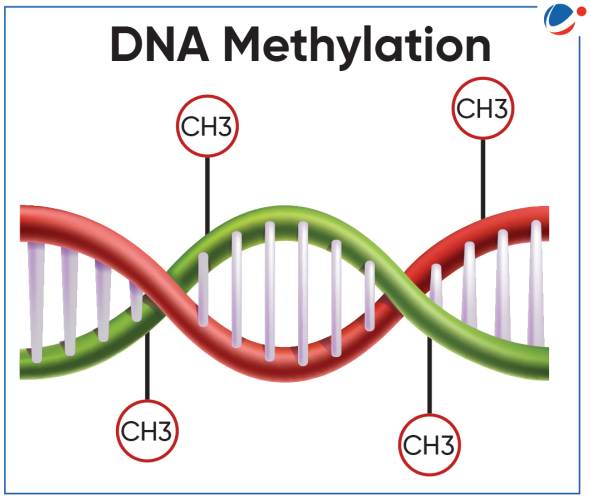
1.5. DIVERSE EPIGENETIC EPIDEMIOLOGY PARTNERSHIP (DEEP)

Why in the News?

CSIR-Centre for Cellular and Molecular Biology (CCMB) is collaborating with research groups across the world on the **Diverse Epigenetic Epidemiology Partnership (DEEP) project.**

What is Epigenetic Epidemiology?

- Part of epidemiology (**patterns and factors related to health and disease** in populations).
- **Epigenetics** is the study of how your behaviours and environment can cause changes that affect the way your genes work.
  - **Unlike genetic changes**, epigenetic changes are reversible and do not change the DNA sequence, but they can change how body reads a DNA sequence.
- One common epigenetic modification is **DNA methylation.**
- Involves the **addition of a methyl group to the DNA molecule** (refer to the infographics).
  - **High levels of DNA (DeoxyriboNucleic Acid) methylation** lead to **gene silencing**.



Gene silencing

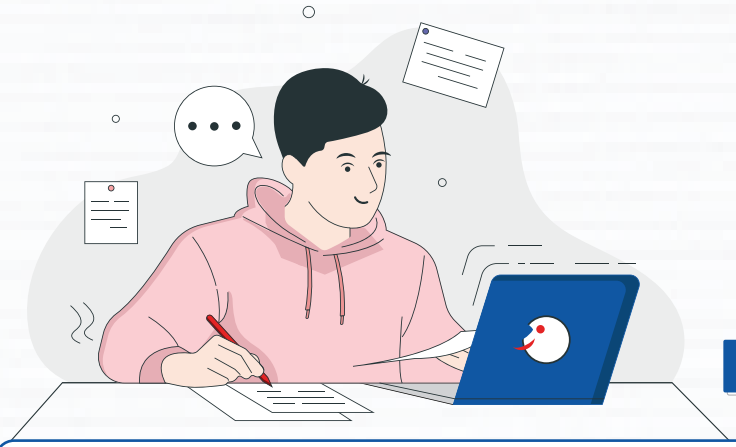
- New treatment technique that **makes use of the body's natural processes** to control disease by suppressing or 'silencing' specific genes that are associated with certain diseases.
- Means **temporarily blocking a specific gene's message** that would otherwise trigger an unwanted effect.

About DEEP Project

- A **five-year project** led by **researchers at the University of Bristol, London** and the CSIR CCMB **in India.**
  - **CRSIR is national R&D Centre** to promote scientific, industrial and economic growth with its **president as Prime Minister of India.**
- **Rationale:** Much of the population health research conducted till date has drawn heavily on data collected from people of **white European origins.**
  - Many global communities are **under-represented** in health studies**.**
- **Procedure**:
  - Generate **genomic datasets in underrepresented populations** across African, Asian (including India), and North and South American continents.
  - **Analyse DNA methylation data** and **health-related measures from people around the world**, and identifying the causes and mechanisms of these health outcomes.
- **Significance:** Understand the genetics behind Non-Communicable Diseases (NCDs) in diverse populations.

Related Development
Genetic Markers

- Recently, Indian scientists have identified **single nucleotide polymorphisms (SNPs)**, or **genetic markers** that have been **associated with preterm or premature birth.**
  - These scientists were working in **Garbh-Ini programme**
    - ✓ **GARBH-Ini** is an initiative under **Department of Biotechnology** to elucidate **biological and non-biological risks of PTB**.
- **Genetic markers** can be defined as **specific DNA sequences** with a known location on a chromosome and are essential tools for linkage and association studies.
  - In it, **Polymerase chain reaction (PCR)** can be used. It is a laboratory technique for rapidly producing (amplifying) millions to billions of copies of a **specific segment of DNA**.



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Smart and Effective UPSC Prelims Preparation Strategy

The UPSC Prelims is the first and highly competitive stage of the Civil Services Examination. It comprises two objective-type papers (General Studies and CSAT) designed to test a candidate's knowledge, understanding, and aptitude.

This stage challenges aspirants to not only master a broad syllabus and adapt to changing patterns but also excel in time management, information retention, and navigating the Prelims unpredictability.

Achieving success in this exam transcends mere hard work; it necessitates a holistic and adaptive approach to preparation.

Scan QR Code for **Instant Personalized Mentoring**

Key Strategies for Prelims Preparation

Strategized Preparation Plan: Allocate your study time wisely across subjects, ensuring you have enough time for revision and practice mocks. Pay attention to your weak areas.

Resource Optimization: Choose study materials that are both thorough and to the point. Focus on quality over quantity to prevent getting overwhelmed.

Strategic Use of PYQs and Mock Tests: Use past year papers to understand the exam pattern, important topics, and question trends. Regularly practicing and assessing progress with mock tests improves preparation and time management.

Systematic Current Affairs Preparation: Keep abreast with Current affairs through newspapers, magazines and integrating this knowledge with static subjects to improve understanding and retention.

Smart Learning: Focus on understanding concepts rather than rote learning, use mnemonics, infographics, and other effective learning tools for better retention.

Seeking Personalized Guidance: Engage with mentors for customized strategies, areas to improve, and motivation. This mentorship also helps in stress management, guiding you through effective practices to maintain mental well-being.

Keeping the needs of the UPSC Prelims examination, the VisionIAS has brought its much-celebrated **All India GS Prelims Test Series and Mentoring Program** which encompass the entire UPSC syllabus based on the latest trends.

Scan **QR code** to watch **"UPSC Prelims 2024: Effective Strategy for 3.5 Months"**

Its key Features include:

- Comprehensive coverage of the UPSC syllabus
- Flexible test series schedule
- Live online/offline test discussion and post-test analysis
- Answer keys and comprehensive explanation for every test paper
- Individualized Personal Mentoring
- Innovative Assessment System and Performance Analysis with All India Rankings
- Quick Revision Module (QRM)

Ultimately, a strategic, well-rounded preparation combining smart study plans, practice, focused resources, and personalized guidance is key to navigating the UPSC Prelims successfully.

Scan **QR code** to **register** and **download brochure** "All India GS Prelims Test Series and Mentoring Program"

2. IT AND COMPUTER

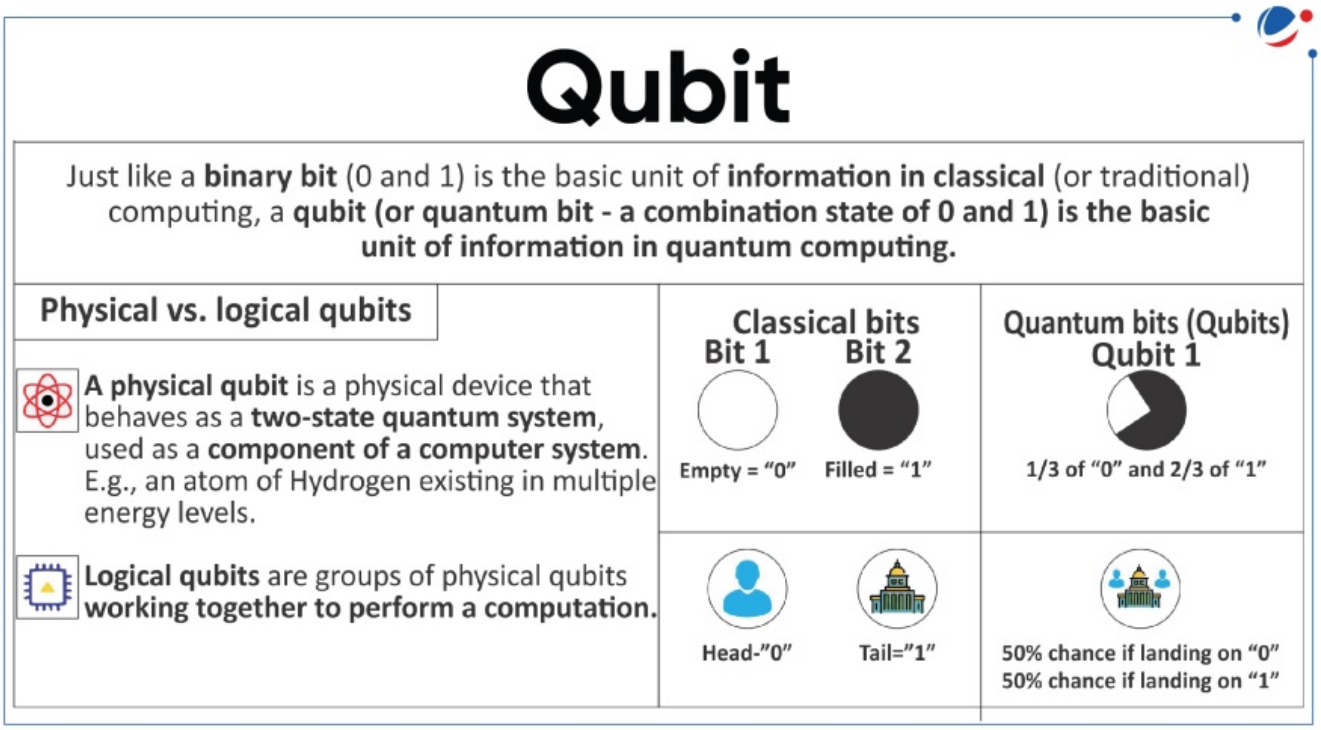
2.1. NATIONAL QUANTUM MISSION (NQM)

Why in the News?

The **1st meeting of Mission Governing Board (MGB) of** National Quantum Mission (NQM) discussed implementation strategy and timelines of NQM as well as the **formation of Mission Coordination Cell (MCC).**

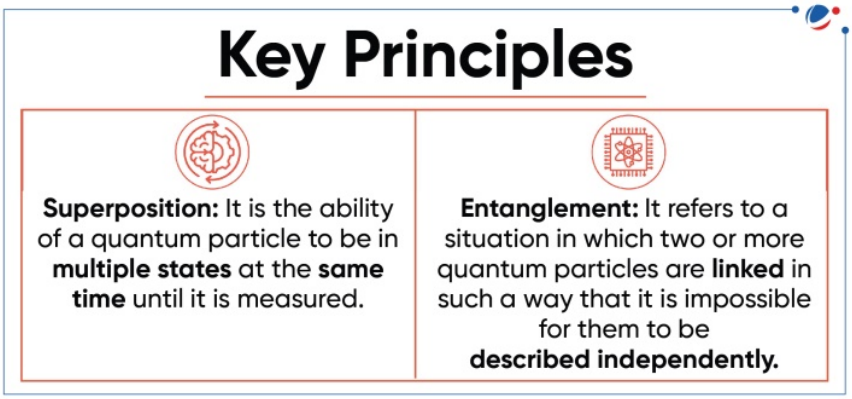
About Mission Coordination Cell (MCC)

- The MCC will be set up as a **coordinating agency for the NQM** and will work in coordination with the **Mission Secretariat, Department of Science of Technology (DST).**
- It will function under the **overall supervision and guidance of Mission Technology Research Council (MTRC).**
- **NQM** was approved by cabinet in 2023 at a total cost of about **Rs. 6000 crores.**



About the Mission

- **Aim: To seed, nurture and scale up scientific** and industrial R&D.
- **Implementing agency:** Department of Science & Technology (DST), the Ministry of Science & Technology.
- **Mission duration:** 2023-24 to 2030-31.
- **Targets:**
  - **Developing** intermediate-scale **quantum computers** with range of 50-1000 physical qubits (refer image).
  - **Developing Satellite-based secure quantum communications between ground stations over a range of 2000 kms within India and with other countries.**



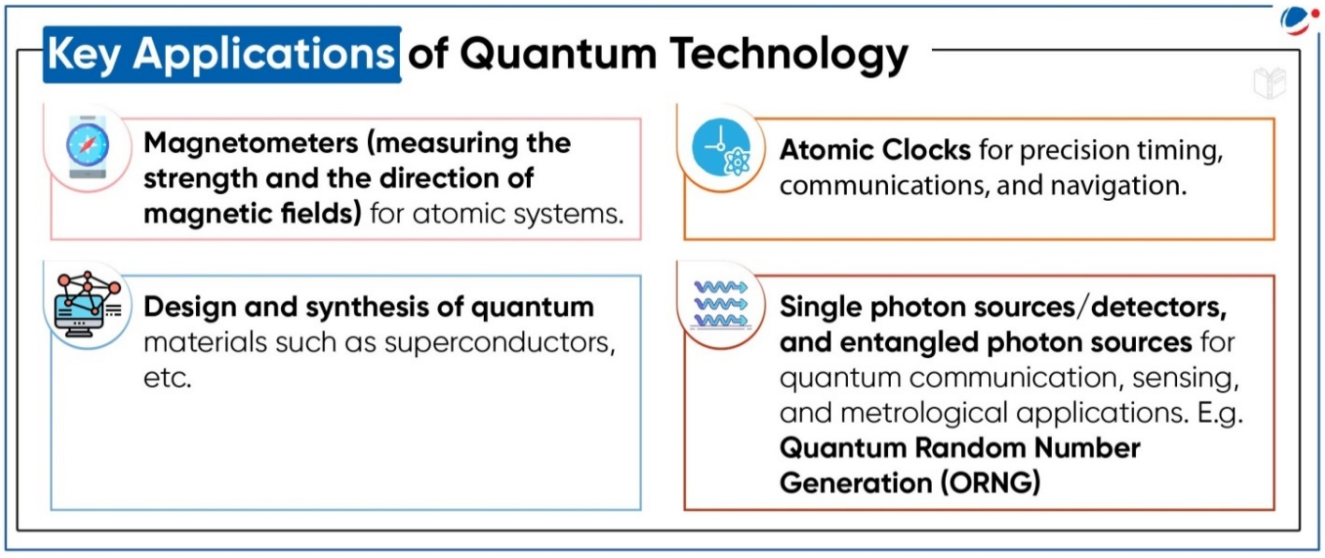
- Along with this developing inter-city quantum key distribution over 2000 km.
  - ✓ **QKD** enables two parties to share information in secure way.

- **Setting up of four Thematic Hubs (T-Hubs) in top academic and National R&D institutes in the domains:**
  - Quantum Computing,
  - Quantum Materials & Devices,
  - Quantum communication,
  - Quantum sensing and metrology.

About Quantum Technology

- Harness laws of **quantum physics** which describes the behaviour of matter and energy at the **atomic** and **subatomic** level.
  - This is **different** from **classical physics in which object exists in one place at one time.**
    - ✓ **E.g. binary physical state (1 and 0).**
- Quantum computers are based on principles like **superposition and entanglement.**

Quantum Computing	Classical Computing
• **High error rates** as they are are **highly susceptible** to noise such as **electromagnetic signals, temperature change and disturbances in the Earth's magnetic field.**	• Low error rates and can operate at **room temperature.**
• **Calculates with qubits,** representing 0 and 1 simultaneously.	• **Calculates with transistors**, which can represent either 0 or 1.
• **Power increases exponentially** in proportion to the number of qubits.	• **Power increases in a 1:1 relationship** with the number of transistors.
• Well suited for tasks like **optimization problems, data analysis, and simulations.**	• Best suited for **most everyday processing tasks.**



Related Concepts
Quantum Coherence

- Refers to the **ability of a quantum system to maintain a well-defined quantum state** over time without being affected by outside disturbances or interactions.
- **In classical physics**, systems tend to **lose coherence over time due to the effects of friction, heat, and other external forces**.
- This property is **essential for various quantum technologies**, such as quantum computing and quantum communication.

- It enables the **creation and manipulation of entangled states and superpositions**, which are the basis of many quantum algorithms and protocols.

Quantum supremacy

- The **experimental demonstration of a quantum computer's dominance** and advantage over classical computers by performing calculations previously impossible at unmatched speeds.

2.2. ARTIFICIAL INTELLIGENCE (AI): REGULATION AND APPLICATION

Why in the news?

The World's first-ever AI Safety Summit was held at Bletchley Park in London (United Kingdom) and it adopted **Bletchley Declaration** to regulate AI.

About Bletchley Declaration

- **World first agreement on Artificial Intelligence (AI)** safety which pledges to work together to assess the risks associated with AI.
- Signed by 28 countries and the European Union. **India is also part of it.**

Key Regulatory Initiatives

- **European Union** AI Act is the **world's first comprehensive AI law**.
- **New Delhi** declaration adopted by **Global Partnership on Artificial Intelligence (GPAI),** a **multi-stakeholder initiative** which aims to bridge the gap between theory and practice on AI by **supporting cutting-edge research** and applied activities **on AI-related priorities**.
  - India's National Artificial Intelligence Portal, 'INDIAai' has also been launched as a one-stop digital platform for AI-related developments in India.
- **Hiroshima AI Process (HAP)**, will be established through a G7 working group, in cooperation with OECD and GPAI.

About Artificial Intelligence

- **Ability** of **machines** to **perform** tasks that would normally require **human intelligence** such as learning, problem solving, and decision making.
- It has different Dimensions:
  - **Generative AI**: Uses deep-learning models like OpenAI's ChatGPT, Google's Bard, Sora, DALL.E, **Krutrim (India's AI Model)** to create high-quality content like text, speech, etc.
    - ✓ Leverages advanced **Natural Language Processing**.
    - ✓ GPT (Generative Pre-Trained Transformers) belongs to the family of Large Language Models (LLM).
      - LLM are **Machine Learning model** based on **neural networks** that can recognize, summarize, translate, predict, and generate content using very large datasets.
      - **Transformer** is a **two-part neural network** (consists of Encoder and Decoder).
    - ✓ **Graphical Processing Units (GPUs)** also play key role in it.
  - **Multimodal AI**: Combines the power of multiple inputs to solve complex tasks such as text to speech, etc.
  - **Frontier AI**: Highly capable general purpose AI models that can perform a wide variety of tasks (exceed the capabilities most advanced models).

Differences between Machine Learning and Deep learning

Sphere	Machine Learning (ML)	Deep Learning
About	• ML is an AI methodology. Not all ML is deep learning.	• Deep learning is an advanced ML methodology. **All deep learning is ML**.
Problem solving approach	• Solves problems through statistics and mathematics.	• Combines statistics and mathematics with **neural network architecture**.
Training	• Need to manually select and extract features from raw data and assign weights to train an ML model.	• Able to self-learn by using feedback from known errors.
Resources required	• Less complex and has a lower data volume.	• **More complex** with a very high data volume.

Key Applications of AI

Healthcare
- **Higher-quality patient care Clinical research (E.g. antibiotic abaucin)**
- **Healthcare supply chain resilience** (Predictive models)
- **Workforce optimization**
- **Disease diagnosis**

Multimodal AI
- **Business Analytics** (machine learning algorithms can recognize different types of information)
- **Data processing** (Generating
- textual descriptions, transcription of videos, etc.)

Agriculture
- **Intelligent crop planning** (using models such as **precision agriculture).**
- **Smart Farming** (World Economic Forum is implementing **AI for**
- **Agriculture Innovation (AI4AI) initiative)**
- **Farmgate-to-fork** (Market-based intelligence, etc.)
- **Data-driven agriculture**

Other Sectors
- Bring down electricity consumption in industrial units
- **Promote innovation and entrepreneurship** from young age (E.g. YUVAi (Youth for Unnati and Vikas with AI)
- In defence, AGNI-D - for surveillance has been developed.
- Developing self-driving cars and Improves traffic management

About Neural Networks

- A neural network is a machine learning program, or model, that **makes decisions in a manner similar to the human brain**, by using processes that mimic the way biological neurons work together to identify phenomena, weigh options and arrive at conclusions.
- Every neural network **consists of layers of nodes, or artificial neurons—an input layer, one or more hidden layers, and an output layer.**
- Neural networks are sometimes called **artificial neural networks (ANNs) or simulated neural networks (SNNs)**.
- There are different types of neural networks like **Feedforward neural networks, or multi-layer perceptrons, (MLPs), Convolutional neural networks (CNNs), Recurrent neural networks (RNNs) etc.**

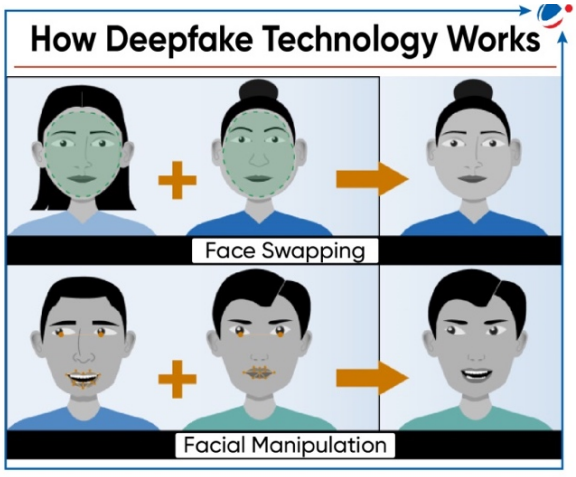
2.2.1. DEEPFAKES

Why in the news?

Union Government issued an advisory to **social media intermediaries to identify misinformation and deepfakes.**

About Deepfakes

- Refers to a **video/image that has been edited using an algorithm to replace a person** in the original video/image with someone else, in a way that makes the video look authentic.
- Can be an imitation of a **face, body, sound, speech, environment, or any other personal information manipulated** to create an impersonation.
- **Uses a form of artificial intelligence** called deep learning to make images of fake events, events that haven't happened.



- Deep learning is a **machine learning subset, using artificial neural networks** inspired by the human brain to learn from large data sets.

Mechanism

- Uses **technologies of deep learning, AI and photoshopping** to create images of events.
  - **GANs (Generative Adversarial Networks) (a class of Machine Learning)** are interplayed to create the videos.
  - GANs consist of generators and discriminators.
  - **Generators take the initial data** set to create new images.
  - Then, the **discriminator evaluates the content** for realism and does further refinement.
- Also, employ **a variational auto-encoder**.
  - A type of **artificial neural network (information processing paradigm)** enabling a **versatile "face swap" model**.

Regulatory measures applicable to deepfakes

- **Legal provisions in India:** In India, there are **no specific legal provisions against deepfake** technology. However, some laws indirectly address deepfake, such as
  - **Section 66E and Section 66D of the IT Act of 2000** and **Indian Copyright Act of 1957.**
- **Global measures against Deepfakes: Google announced tools for Watermarking** to identify synthetically generated content.

2.3. WEB 3.0

Why in the News?

Recently, the report titled "Unlocking the Web3 Potential: India's Journey from a Talent Exporter to a Product Powerhouse" was released Primus Partners (private organisation).

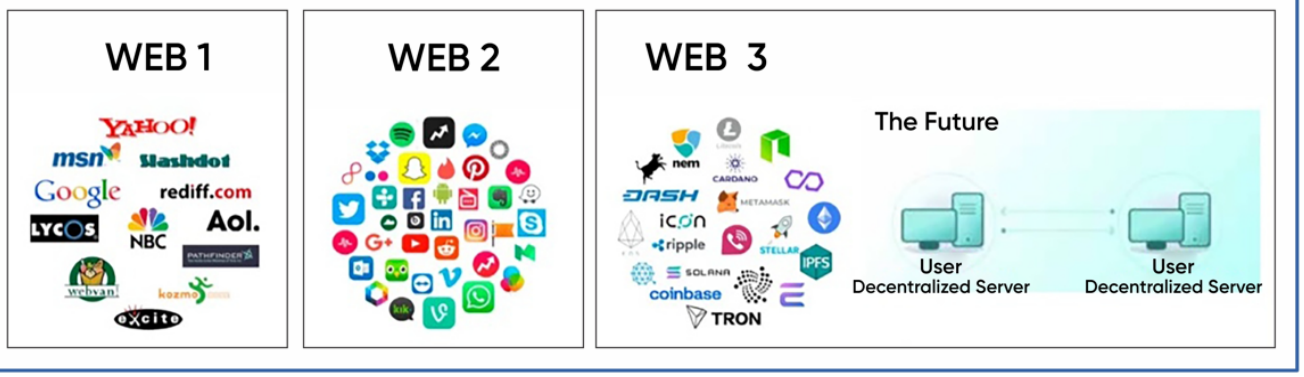
Key findings

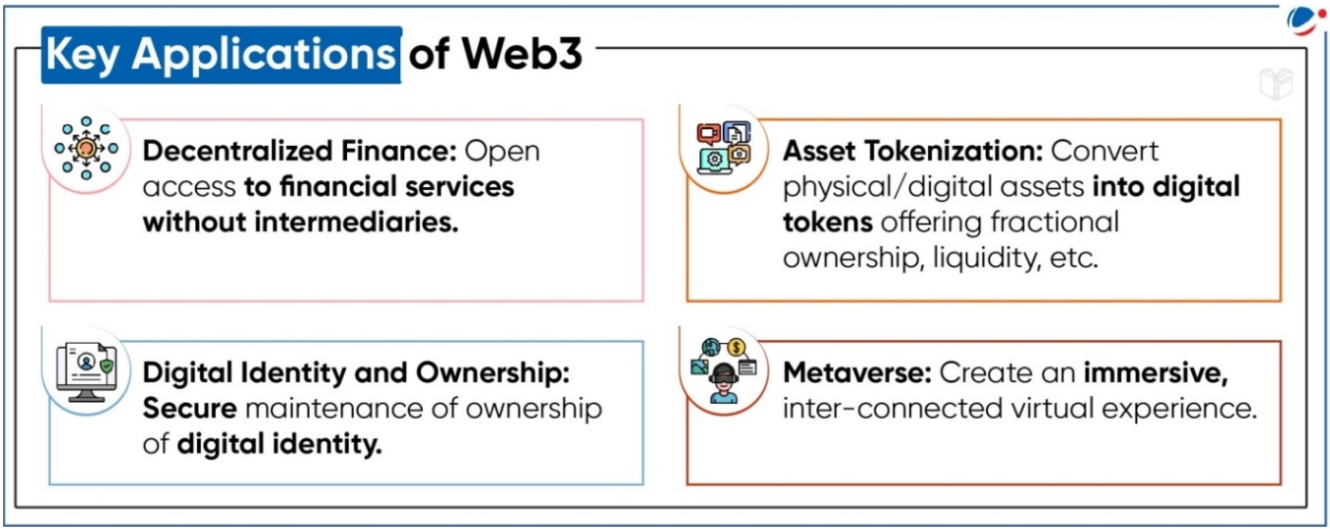
- In 2022**, India held 11% of the global Web3 developer pool**, ranked 3rd worldwide.
- **Web3 sector is projected to create 2.2 million direct jobs** in India in next decade.

About Web3

- Web3 provides a version of the web where users have a **financial stake** and **more control over** the **web communities** they belong to.
  - **Web 1** also called the **Static Web**, enabled easy **access to information.**
  - **Web 2** built on advancements in **web technologies**, enabled **interactive platforms** e.g., Facebook etc. It is **centralized** in nature and relies heavily on intermediaries.
- **Web3** enables **peer-to-peer transactions and interactions without intermediaries.**
  - Includes **cryptocurrencies**, **Non-Fungible Tokens**, **Decentralized Autonomous Organizations** (DAOs), etc.
  - **Provides more security of data** in comparison to Web 1 and Web 2.
  - Enables people to **control their own data**.
  - **Blockchain based social networks**.
  - **Operated by users collectively** rather than a corporation.
- **Web 4.0** also known as the **Symbiotic web** which will **aim at the interaction between humans and machines in symbiosis.**
- **Web 5.0** features include **control over identity**, a **decentralized platform for storing data**, and a **free-flowing environment for creators to develop decentralized ap plications**.

Comparison between Web 1.0, Web 2.0 and Web 3.0





Related Development & Concepts

Design and Development of a Unified Blockchain Framework for offering National Blockchain Service and Creation of Blockchain Ecosystem' Project

- Recently, this project was released by **Centre for Development of Advanced Computing, India.**
- Project facilitate the creation of Open Application Programming Interfaces (APIs) for **smooth integration and provision of blockchain-as-a-service (BaaS).**
  - **BaaS is a Third-party cloud-based infrastructure** and **management** for **companies**.
    - ✓ Allows Government Departments to **leverage Blockchain services.**
    - ✓ Helps in **building**, **hosting** and use their own blockchain apps, smart contracts and functions on blockchain.
- Launched in accordance with **National Strategy on Blockchain, 2021** (released by **Ministry of Electronics and Information Technology.)**

About Blockchain Technology

- **Distributed** & **decentralised ledger technology.**
- Facilitates recording and tracking transactions between users.
- Each **transaction** is recorded as a **"block" of data.**
  - It is **linked with** other **blocks before or after it.**

Software as a Service (SaaS)

- **SaaS** is a **cloud-based software delivery model.**
- In it, **cloud provider develops and maintains** cloud application software.

- **E.g.**, email services, **office tools like MS Office 365**, cloud-based data storage like Google Drive, **Outlook, Hotmail and Yahoo! Mail** etc.
- SaaS buyers can **customise the user interface and can change data fields.**
- SaaS users can **access their data through their mobile devices**.

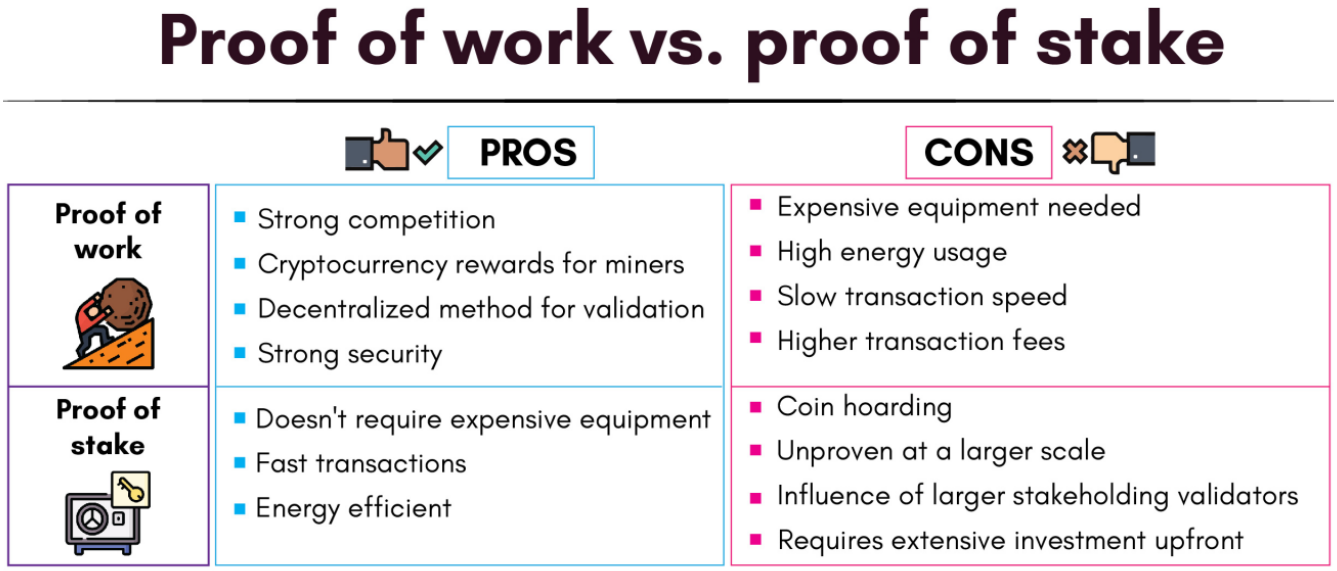
2.4. CRYPTO MINING

Why in news?

Recently, Bhutan and Singapore-based Bitdeer have announced plans to **raise $500 million to set up crypto mining operations in the Himalayas that is free of carbon**.

About Crypto Mining

- Process of **generating new coins** and **verify** & **process new transactions**.
- Involves **vast, decentralized networks of computers** which verify and secure blockchains.
- **Fundamental to proof-of-work (PoW) cryptocurrency** networks like **Bitcoin (BTC)**.
  - **Proof of work and proof of stake** (PoS) use algorithms to validate cryptocurrency.
  - The main difference between PoW & PoS is **how they choose and qualify users to add transactions.**
  - PoW and PoS are **protocols intended to validate transactions and keep the blockchain network decentralized and secure.**
  - PoW is a **mechanism bitcoin uses to regulate the creation of blocks** and the integrity of the network through the process of mining.
  - PoS is an **alternative consensus mechanism** that delegates control of the network to the owners of a given token.



- **Different types of Crypto Mining:**
  - **Central Processing Units (CPUs) mining**: **Uses processors**.
  - **Graphics Processing Units (GPUs) mining**: **Uses graphics cards to mine crypto**.
  - **Other types** include Application-Specific Integrated Circuits (ASICs) mining, Field-Programmable Gate Array (FPGA) mining, Cloud Mining etc.

Related Concepts
Cryptocurrency

- Decentralized digital money that is based on **blockchain technology and secured by cryptography.**
- A **subset of virtual currencies (**a digital representation of value that can be digitally traded).
  - Cryptography uses mathematical techniques (**Cryptographic Key**).
    - ✓ It transforms data and prevent it from being read or tampered with by unauthorized parties
- **E.g. Bitcoin, Ethereum** etc.

2.4.1 MARKETS IN CRYPTO ASSETS (MICA)

Why in the news?

The European Parliament has recently passed the Markets in Crypto Assets (MiCA) legislation, to regulate the Crypto industry.

About Markets in Crypto Assets (MiCA)

- Established a legal framework for **crypto-asset services providers as well as consumer protection.**
- Focuses on certain categories of crypto assets which are currently out of the scope of existing regulations.
- **Sub-Categorisation of Crypto assets:** Electronic Money Tokens (EMTs), Asset Referenced Tokens (ARTs), and Utility Tokens (UTs).
- Does **not apply** to **non-fungible tokens (NFTs), DeFi (Decentralized Finance) & Central bank digital currencies (CBDCs)**.
  - **DeFi** is an emerging model for organizing and enabling cryptocurrency-based transactions, exchanges and financial services.

Crypto Asset

- **A crypto asset is** a digital representation of value or rights which may be transferred and stored electronically.
  - It uses distributed ledger technology or similar technology.

Different types of Tokens under Crypto Assets

- **Stablecoin (also known as electronic money tokens):** Values are fixed; often they are pegged to a currency such as the US dollar.
- **Security tokens:** Indicate that the owner possesses a stake in some real world asset or enterprise.
- **Asset tokens**: Represent real-world assets such as gold or real estate.
- **Utility tokens:** Users with special access to a product, service, or offer, and are often issued as part of a project or company's initial coin offering (ICO).
- **Non-fungible tokens (NFT):** Blockchain-based tokens that each represent a unique asset like a piece of art, digital content, or media.
  - It is an irrevocable **digital certificate of ownership and authenticity for a given asset,** whether digital or physical.
  - They are designed to be **cryptographically verifiable.**
  - The main difference is that every NFT is unique, which sets it apart from fungible tokens, such as cryptocurrency, that can **be traded or exchanged for one another with no loss of value.**

Attempts to regulate Crypto Assets in India

- **2019: RBI held that trading/holding/ mining of Crypto coins in India was illegal** and imposed a fine of 10 Lakhs.
- **2020:** The **Supreme Court nullified the ban by RBI** and advocated the Government to take a decision over the same.
- **2022: A 30% tax was levied on the income earned from the transfer of Virtual Asset,** by the Finance Ministry.
- **2023: All transactions involving Virtual Digital Assets** are brought under the purview of the **Prevention of Money Laundering Act (PMLA), 2002.**
- **2023:** G20 countries adopted the **New Delhi Leaders' Declaration** which called for effective regulation of crypto assets.

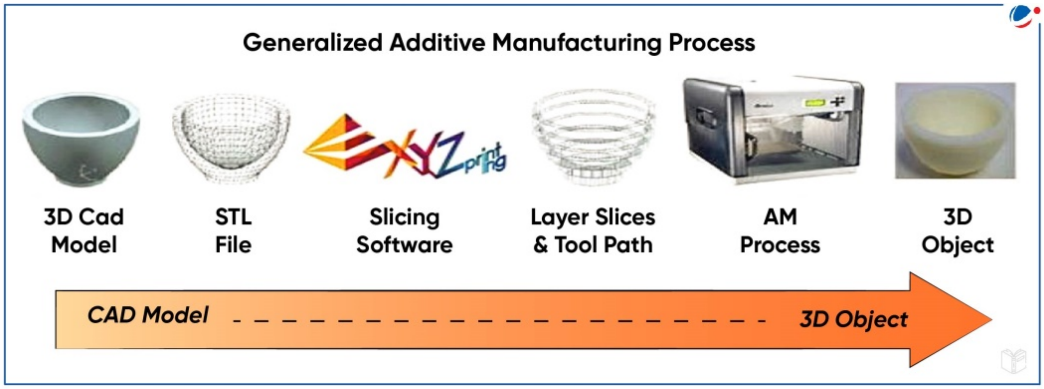
2.5. 3D PRINTING TECHNOLOGY/ ADDITIVE MANUFACTURING

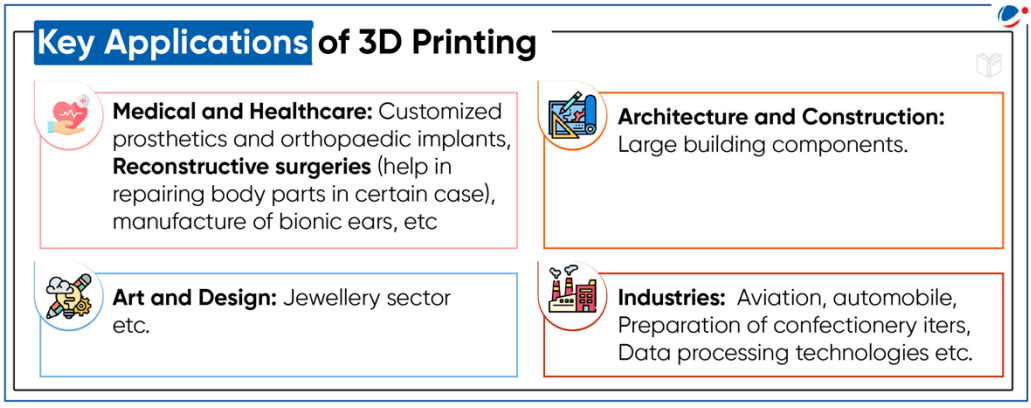
Why in the News?

IIT-Mandi researchers have found that extrusion-based metal **Additive Manufacturing (AM)** process is cost-effective method in comparison to other approaches in metal 3D printing.

About 3D Printing / Additive Manufacturing

- A process in which a **digital model CAD (Computer-aided Design) is turned into a tangible, solid, three-dimensional object**, usually by laying down many successive, thin layers of a material.
- Makes **prototypes** or **working models of objects.**
  - Involves **laying down successive layers of materials** such as plastic, resin, thermoplastic, metal, fiber or ceramic.
  - **Opposite of subtractive (traditional) manufacturing**.
- **Benefits of 3D Printing:** Lower inventory, reduced time, print complex designs, Little or no wastage etc.
- In 2020, Ministry of Electronics and Information Technology released **"National Strategy for Additive Manufacturing" to tap its potential.**
- **Recently,**
  - **India's first 3D-printed post office** was created in Bengaluru.
  - **Telangana unveiled world's first 3D-printed temple** at Burugupally, Siddipet district.





About 4-D printing

- A renovation of 3D printing wherein **special materials is used to print objects that change shape post-production.**
- Need **Stimuli** or **triggers** to start transformation: Such as **moisture, temperature, light, electrical current, stress, pH etc.**
- **Materials used**: Hydrogels, Thermo-responsive, Photo and magneto responsive, Piezoelectric materials, pH-responsive etc.
- **Properties**: Self-assembly, self-adaptability, self-healing, shape memory, self-capability etc.

2.6. WI-FI 7 TECHNOLOGY

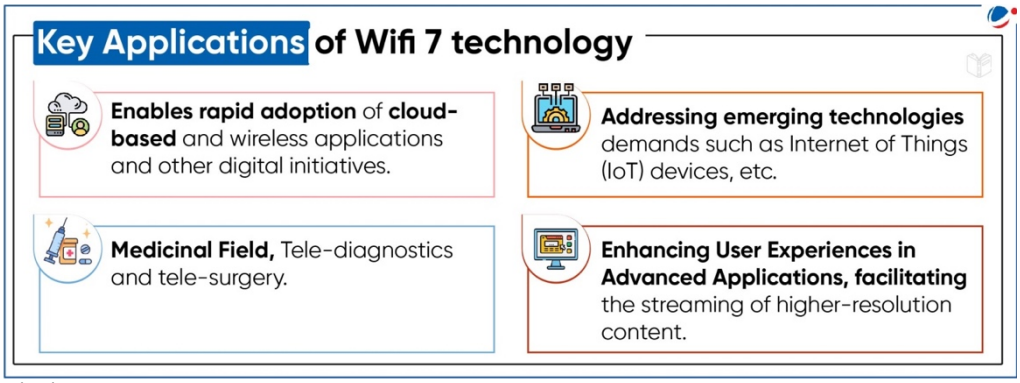
Why in the news?

Recently U.S. based company Qualcomm suggested that India should adopt the newest **Wi-Fi 7 technology**.

About Wi-Fi 7 (Wireless Fidelity)

- **Wi-Fi 7** is the next-generation Wi-Fi standard.
- Based on **IEEE 802.11be** — extremely high throughput (EHT).
  - **Institute of Electrical and Electronics Engineers (IEEE)** is the world's largest technical professional organization.

- **Key Features of Wi-Fi 7**
  - **Backward Compatibility** (Connects with devices of different bands)
  - **Lower Latency and Multi-Link Operation** (MLO)
  - **Speed and Capacity** (Four times faster than Wi-Fi 6)



- Wifi **uses radio waves**.
  - Needs **three medium**:
    - ✓ Base station
    - ✓ Router
    - ✓ Accessing devices (like Phone, Laptop, etc.)

Comparison of Wi-Fi generations

	Wi-Fi 4	Wi-Fi 5	Wi-Fi 6/6E	Wi-Fi 7
Peak Speed	600 Mbps	7 Gbps	9.6 Gbps	36 Gbps
Frequency Bands	2.4 Ghz, 5 Ghz	5 Ghz	2.4 Ghz, 5 Ghz	2.4 Ghz, 5 Ghz, 6Ghz
Key Advances	Introduced **MIMO (Multiple Input, Multiple Output)** technology for improved data transfer rates and reliability.	Introduced wider channels, **MU-MIMO (Multi-User-MIMO),** and **Beam- forming** for increased data transfer speeds and better handling of multiple devices.	Introduced features like **OFDMA (Orthogonal Frequency Division Multiple Access)**	Key features include backward compatibility, multi-link operation **(MLO),** and support for **wider channels** (up to **320MHz)** and **Adaptive puncturing technology**
Launch	2009	2013	2019	2024 (Expected)

2.7. FACIAL RECOGNITION TECHNOLOGY

Why in the news?

Ministry of Communications has developed an AI-based facial recognition tool **Artificial Intelligence and Facial Recognition powered Solution for Telecom SIM Subscriber Verification (ASTR).**

About ASTR

- Launched **under Sanchar Saathi Initiative**.
- An **AI powered tool** to **identify SIMs issued using fraudulent/ forged documents.**

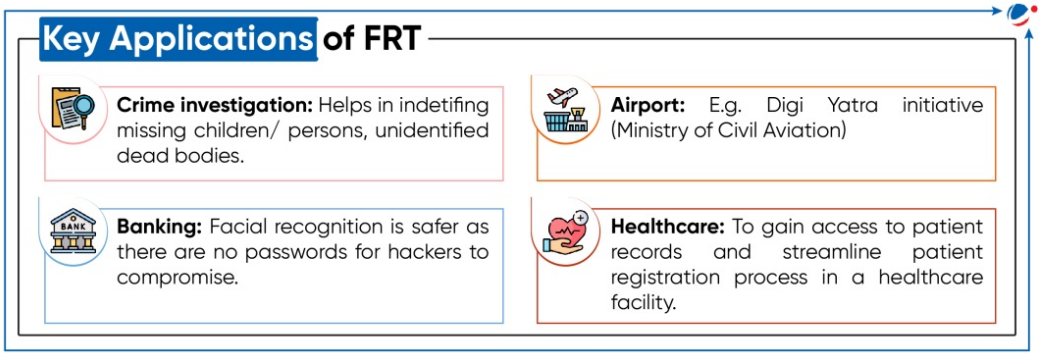
About Sanchar Saathi Initiative.

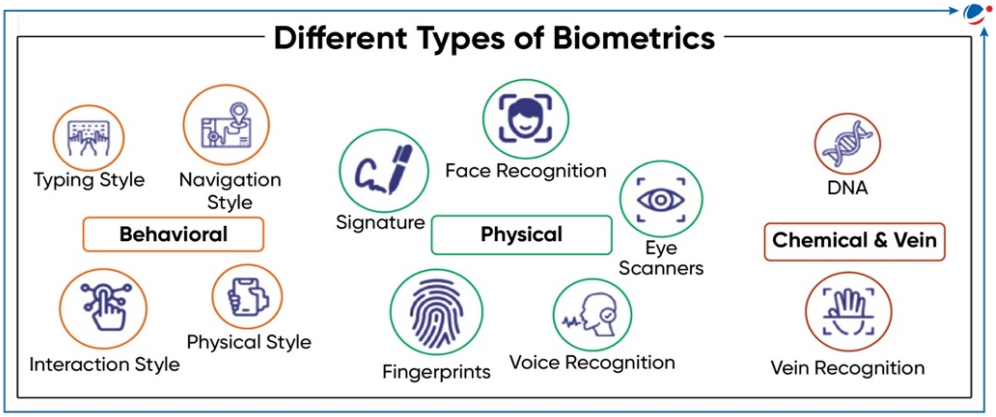
- Initiative helps **citizens to know the mobile connections issued** in their name; report fraudulent etc.
- **Developed by:** Department of Telecommunications
- It **includes following modules**
  - CEIR (Central Equipment Identity Register) - for blocking stolen/lost mobiles.
  - Know your mobile connections - to know mobile connections registered in your name.
  - Telecom Analytics for Fraud Management and Consumer Protection (TAFCOP)
  - Artificial Intelligence and Facial Recognition powered Solution for Telecom SIM Subscriber Verification (ASTR).

- **Param-Sidhhi Supercomputer** was used for large data processing.
- Use **convolutional neural network (CNN) models.**

About Facial Recognition Technology (FRT)

- Way of identifying or confirming **an individual's** identity using **their face.**
- Can be used to **identify people in photos, videos,** or **in real-time**.
  - **Computer algorithms map unique facial-landmarks** such as shape of cheekbones, contours of lips etc.
  - **And, convert these into a numerical code**— termed a faceprint.
    - ✓ Relies on many of the processes and techniques associated with AI.
  - For verification or identification, **system compares faceprint generated with a large existing database** of faceprints.





2.8. SUPER COMPUTERS

Why in the news?

India's AI supercomputer AIRAWAT has been ranked 75th in the Top 500 Global Supercomputing List.

About AIRAWAT

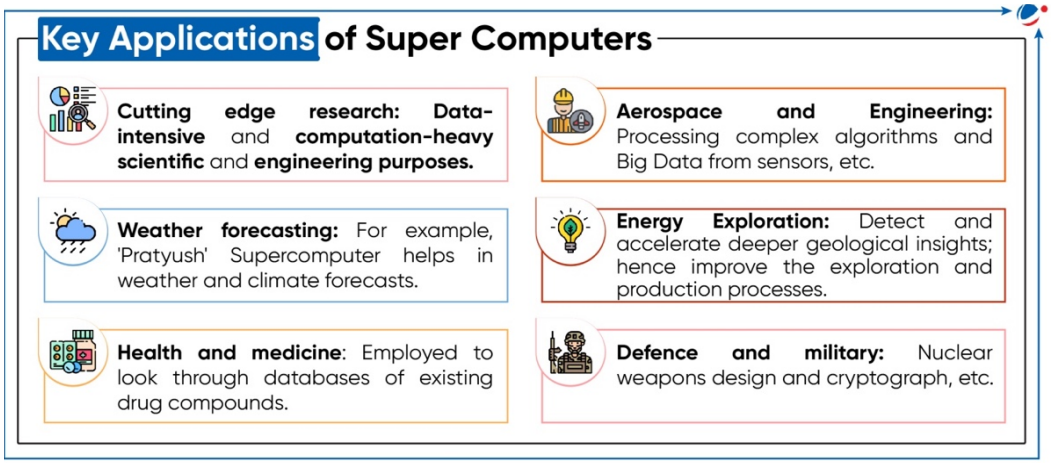
- Installed at the **Centre for Development of Advanced Computing (C-DAC)** in Pune, Maharashtra
- **India's largest** and **fastest AI supercomputing system**, with a speed of 13,170 teraflops and works on the **operating system Ubuntu 20.04.2 LTS.**
- Installed under **National Program on Artificial Intelligence** (NPAI).
  - NPAI is an **umbrella programme by the MeitY** for leveraging transformative technologies to foster inclusion, innovation, and adoption for social impact in AI.

About Supercomputer

- A **high-performance computing system** that delivers **exceptional processing power** and **computational capacity** as compared to general purpose computer.
- Performance is measured in **floating-point operations per second (FLOPS)** instead of million instruction per second (MIPS).
- India's other **three supercomputers are in the Top 500 list**: PARAM Siddhi-AI, Pratyush and Mihir.
  - **India's first supercomputer** was **PARAM 8000** (set up in 1991).
  - **PARAM Shivay** was the first supercomputer assembled indigenously in 2019 under **National Supercomputing Mission (NSM).**

National Supercomputing Mission (NSM)

- **Launched in 2015.**
- **Goal**: To connect R&D institutions and academic institutions using a supercomputing grid with more than 70 high performance computing facilities.
- **National Knowledge Network (NKN)**: These supercomputers will be networked on the National Supercomputing grid over the NKN.



- **Jointly steered by**: Department of Science and Technology (DST) and Ministry of Electronics and Information Technology (MeitY).
- **Implemented by**: Centre for Development of Advanced Computing (C-DAC); Indian Institute of Science (IISc), Bengaluru.

Related Development
Digital India RISC-V Microprocessor (DIR-V) Program

- MeitY launched the **DIR-V program.**
- **Enable** the creation of **next-generation microprocessors** in India.
- Help in ensuring **partnership between startups, academia, and multinationals** to make India a **RISC-V Talent Hub** and **supplier of RISC-V system of chips.**
- **About Reduced Instruction Set Computer - V (RISC-V)**
  - **Open-source instruction** set architecture.
  - Used **to develop cwustom processors** for a variety of applications, from embedded designs to supercomputers.
- **Applications:** Wearable appliances, smartphones, the Internet of Things (IoT), High-performance computing, data centers, etc.

2.9. NET NEUTRALITY

Why in the News?

Start-ups have written to Telecom Regulatory Authority of India (TRAI) opposing Telecom Service Providers (TSPs) push for regulating Over the Top (OTT) services.

What is Net Neutrality?

- An **open, equal internet for everyone, regardless of device, application or platform** used and content consumed.
- **All corporations,** including **internet service providers (ISPs), should treat internet data and users equally**.
  - Should not restrict access, slow down access speeds or block content for some users.
- The **TRAI** released a new framework called the **'Prohibition of Discriminatory Tariffs for Data Services Regulations, 2016'**.
  - **Barred telecom service providers from charging differential rates** and ensured net neutrality.

About Over The Top (OTT) Service

- A **content, a service or an application** that is **provided to the end user over the public Internet.** Classified into two groups
  - **OTT communications services**, e.g. Whatsapp, Telegram etc.
  - **OTT application services** – Include all other OTT services such as media services, trade and commerce services, cloud services, social media e.g. Facebook, Amazon, Netflix etc.
- Recently, Telecom Disputes Settlement and Appellate Tribunal (TDSAT) held that **OTT streaming platforms do not fall under the jurisdiction of the Telecom Regulatory Authority of India (TRAI).**
- Do not **require any permission or a license from the Union government**.
- **Governed under the Information Technology Rules, 2021,** notified by the IT Ministry.

2.10. 5G ECOSYSTEM

Why in the News?

Telecom Regulatory Authority of India (TRAI) released Consultation Paper on Digital Transformation through 5G Ecosystem.

About 5G (5th generation mobile network)

3rd Generation Partnership Project (3GPP)

- It unites **seven telecommunications standard development organizations,** known as "Organizational Partners".
- 3GPP specifications cover **cellular telecommunications technologies**, including radio access, core network and service capabilities.
- Currently, **3GPP is defining standards for 5G.**

- A **global wireless standard** after 1G, 2G, 3G and 4G networks.
  - Deliver **higher multi-Gbps peak data speeds, ultra-low latency, more reliability, massive network capacity,** increased availability, and uniform user experience to users.
- **Private 5G:** Also known as captive non-public network (CNPN).
  - A network that is set up solely for a firm's own use and is a closed user group.
  - Essentially a local area network that uses **3GPP-based network spectrum**.
  - **Benefits of private 5G**: Improved speeds, Enhanced data security, Controlled latency and Customization.
- It has various applications like in **enhanced grid management, robotic surgeries, drones** etc.
- **Government's Initiative to facilitate 5G services:**
  - **5G Test Bed** for start-ups and MSMEs
  - **Bharat Net** connecting rural India on optical fibre network
  - **5G High Level Forum, Fiberisation etc.**

6G (6th generation mobile network)

- **Successor** of **5G.**
- Ability to use **higher frequencies (**Sub-6 GHz and 95 GHz to 3 THz (Terahertz)**)** with **greater speed (**Up to 1,000 Gbps**)** and **lower latency (**1 millisecond**).**
  - **Significance**: Support **high-performance computing, edge computing, Technology Convergence** etc.
- Department of Telecommunication (DoT) launched **Bharat 6G Alliance (B6GA)**.
  - B6GA is a **collaborative platform comprising public and private companies**, academia, research institutions, and Standards development organisations.

2.11. FREE SPACE OPTICAL COMMUNICATION (FSOC)

Why in the News?

Alphabet, under **Project Taara** is currently deploying their light beam internet technology in India, Africa, etc. Project Taara utilises **Free Space Optical Communication (FSOC)**.

About FSOC

- An **outdoor optical wireless communication (OWC).**
  - **Short-distance (Largely indoor) OWC** is called **light Fidelity (LiFi).**
  - **LiFi uses light** within **Visible Light Spectrum** to Invisible light spectrum **to transmit data.**
    - ✓ **LiFi** works based on VLC (Visible Light Communication) principle.
    - ✓ VLC can transmit large amounts of data faster than Bluetooth.
    - ✓ It has no electromagnetic interference.
  - A **LOS (line of sight)** technology.
  - Data, voice, and video communication is achieved with maximum 10Gbps of data rate by full-duplex (bidirectional) connectivity.
  - Working is similar to **OFC (optical fiber cable) networks** but the only difference is that the optical beams are sent through free air instead of OFC cores that are glass fiber.

Comparison between Li-fi and Wi-fi

Parameter	Li-fi	Wi-fi
Speed	>1 GB/s	Around 150mb/s
Medium of data transfer	Use light as carrier	Use radio spectrum
Spectrum range	Wider Spectrum	Having less spectrum range than VLC
Cost	Cheaper	Expensive
Network topology	Point-to-Point	Point-to-Point
Operating Frequency	Hundreds of Tera Hz	2.4 GHz

- **Advantages:** Cost-effective and quickly deployable, can transmit data at high speeds, etc.
- **Applications:** Military applications, Last-Mile access, Telecommunication and computer networking etc.
- **Challenges faced:**
  - Signal reliability is compromised by conditions like fog and haze.
  - Interruptions like birds flying in front of the signal.
  - Requires better mirror controls and motion detection capabilities etc.
- **Earlier Alphabet** tried to deliver internet through **Project Loon** utilising stratospheric balloons for internet connectivity.
- **Starlink satellites** have also been **developed by SpaceX to provide internet to remote locations.**

2.12. ORGANIC LIGHT EMITTING DIODES (OLED)

Why in the News?

Researchers at the University of Chicago have developed an OLED material.

About OLED

- A **flat light emitting technology** made by placing a **series of organic thin films** between two **conductors**.
  - When electrical current is applied, a bright light is emitted.
- OLED displays **can be fabricated on flexible plastic substrates**.
- **Roll-up displays embedded in clothing** can be made using OLEDs.
- **Transparent displays** are possible using OLEDs.
- **AMOLED (active-matrix organic light-emitting diode)** and **Super AMOLED** are display technologies used in Mobile devices and televisions.
- **Comparison of different display technology-**

Display Technology	LCD (Liquid crystal display)	OLED	mLED
Pixel types	Back lit display	Self-emissive display	Self-emissive display
LED makeup material	Inorganic LED backlight	Organic LED	Inorganic LED
Brightness	High	Low	Very high

Lifespan	Long	Short	Very long
Response time	Slow (in milli-seconds)	Medium (in micro-seconds)	Fast (in nano-seconds)

2.13. OTHER IMPORTANT NEWS

2.13.1. METAVERSE

- A **3-D-enabled virtual reality space.**
- **Provides digital experiences as an alternative** to or a **replica of the real world.**
  - Allows people to have lifelike experiences online.
- **Building Blocks of Metaverse** (4 layers)
  - **Infrastructure layer**, enables devices, connects them to the network, and delivers content.
  - **Virtualization engine layer** provides the computational and programming platform.
  - **Interface and Access layer** help users in accessing the Metaverse.
  - **User experience and use cases layer**, creation, sale, trading, storage, etc.

2.13.2. BHAROS

- A Made in **India mobile operating system** developed by IIT Madras.
- It is developed under **project funded by the Department of Science and Technology (DST).**
- It comes with **No Default Apps (NDA)**.
  - This means that users are not forced to use apps that they may not be familiar with or that they may not trust.
- Offers **'Native Over The Air' (NOTA)** updates that can help to keep the devices secure.
- Provides access to trusted apps from organisation-specific **Private App Store Services (PASS)**.

2.13.3. SUBSCRIBER IDENTIFICATION MODULE (SIM) CARDS

- SIM card is a **microchip** that **identifies subscriber on a given network.**
- **Mandatory** for a **mobile phone to connect** to any network.
  - The Network should follow the **Global System for Mobile Communications (GSM) standards**.
- **Other functions: Store information** about its **own ID number,** International Mobile Subscriber Identity **(IMSI)**, etc**.**
- Latest **version** of **SIM is 'e-SIM'.**
  - **eSIM is an embedded SIM,** essentially the **same hardware of a regular SIM card chip**, but now a **permanently embedded part of the motherboard of a watch or smartphone**.
  - Just like a traditional SIM card, eSIMs also function the same way, **acting as a unique identifier for telecom operators**.
    - ✓ However, being attached to the **motherboard also allows re-programming**, letting users switch operators **without having to replace any physical SIM cards.**
  - First established in **2012.**
  - The ability to store multiple SIM profiles in e**SIM also means one can switch between profiles easily,** without the need of activating a SIM repeatedly or physically switching cards repeatedly.
    - ✓ However, in some countries, **an approval from service provider is needed** for transferring eSIM from an existing phone to a new phone.

2.13.4. GATEKEEPERS

- 6 Big Tech companies namely **Apple, Amazon, Alphabet, ByteDance, Meta, and Microsoft** were named as **Gatekeepers** by the EU.
- **Gatekeepers are the companies** to face the **highest level of scrutiny** under the Digital Markets Act (DMA) of the EU.

2.13.5. MAYA OPERATING SYSTEM (OS)

- **Amid increasing cyber and malware attacks** on defence as well as critical infrastructure, Ministry of Defence **to replace Windows OS** with **Maya OS**.
- New OS is **based on** an **open-source platform Ubuntu.**
  - Unlike proprietary software, **everyone has the freedom to edit, modify and reuse** open-source code.
- In addition, an **end-point detection and protection system**, **Chakravyuh,** is also being installed in these systems.

2.13.6. WIRELESS VIBRATION SENSOR

- Israel Defense Forces is using wireless vibration sensors to identify underground tunnels.
- A **wireless vibration** sensor sends data to your systems with **Internet of Things (IoT)** technology.
  - IoT is a network of interrelated devices that connect and exchange data with other devices.
- It captures vibration data with the help of **sensing components** like **accelerometers**.
  - **Accelerometer is also used in-**
    - ✓ **Detection of car crash/collision** which results in the deployment of airbags almost instantaneously.
    - ✓ **Detection of accidental free fall of a laptop** towards the ground which results in the immediate turning off of the hard drive.
    - ✓ Detection of the tilt of the smartphone which results in the rotation of display between portrait and landscape mode.

NEWS TODAY

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News Today is **Daily Current Affairs bulletin** that simplifies newspaper reading and keeps you updated with daily events. It helps aspirants in:

Understanding the development in any news.

Developing an eye for identifying the kind of news that should be read in the newspapers.

Understanding the different technical terms, complex phenomenon appearing in news.

Key Features of News Today Document

- **Sources:** It covers multiple sources like the Hindu, Indian Express, PIB, News on Air, Economic Times, Hindustan Times, the Mint etc.
- **Segments:** It covers primary News of the day, Also in News and special focus on Personalities and Places in News in 4 pages.
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3. SPACE TECHNOLOGY

3.1. CHANDRAYAAN-3

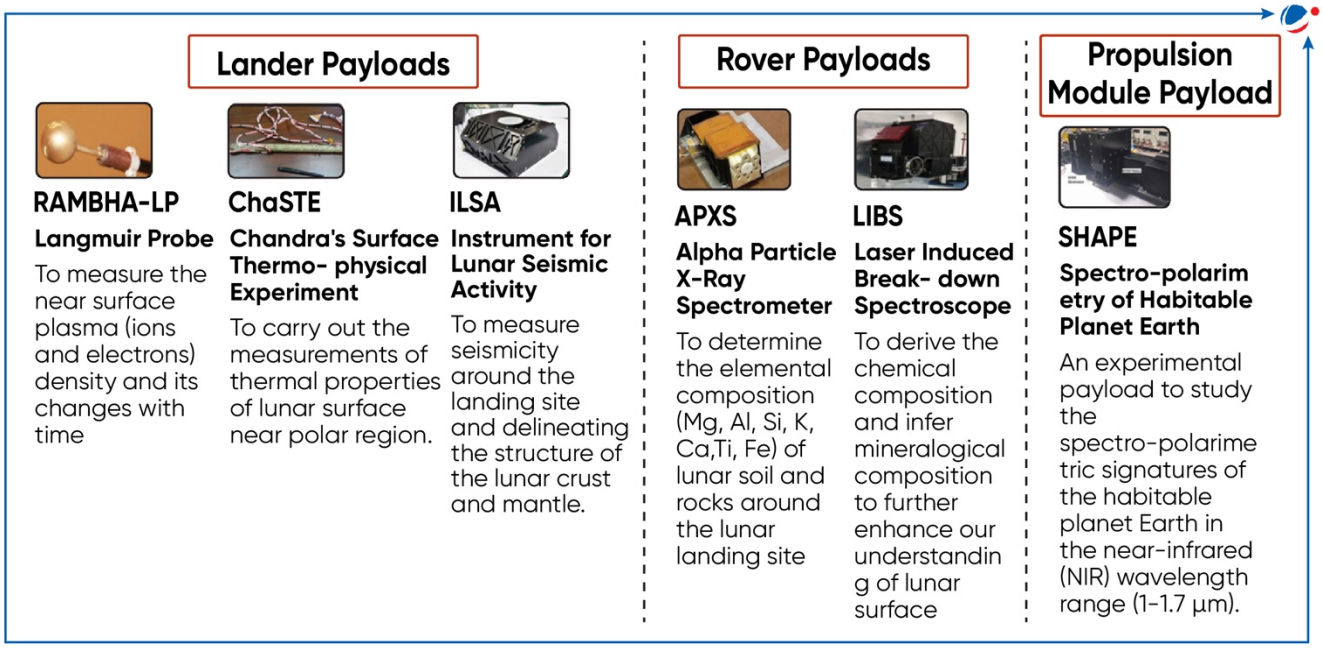
3.1.1. CHANDRAYAAN 3

Why in the news?

Chandrayaan-3 was successfully conducted from **the Satish Dhawan Space Center (SDSC) in Sriharikota.**

About Chandrayaan-3

- **Launch vehicle:** Geosynchronous Satellite Launch Vehicle Mk III
- **Indigenous Payloads:**
  - **Lander module (LM)**
  - **Propulsion module (PM)**
  - **Rover**
- **Objectives**:
  - **Demonstration of a Safe and Soft Landing** on the Lunar Surface
  - **Demonstration of Rover roving** on the moon.
  - Conduct **in-situ scientific experiments.**
- **Successfully underwent a 'hop experiment'** (elevated itself by about 40 cm as expected and landed safely.) This raises hope for **future sample return missions.**



Key findings of Chandrayaan-3

- **Temperature:** ChaSTE payload recorded 70 degrees centigrade temperature.
  - It was believed that the **temperature** could be around 20 to 30 degrees centigrade**.**
- **Elements on the moon:** Laser-induced breakdown Spectroscope instrument confirmed the **presence of sulphur** on the lunar surface near the South Pole.
  - **Other elements** like Aluminum (Al), Calcium (Ca), Iron (Fe), Chromium (Cr), etc. were also detected.
- **Thin plasma:** 'Langmuir probe' finds that there is thin plasma on the surface of the moon.
  - It signifies that **radio waves can easily pass through space.**
- **Natural seismic activity:** ILSA payload indicates a possibility of a quake on the moon.
- **Crater:** Chandrayaan-3 Rover identified a 4-meter diameter crater on the moon's surface.

- **Lunar Soil:**
  - Pragyan Rover has been unable to leave clear imprints of **Indian emblem and ISRO logo on lunar soil.**
  - ISRO explained that **lunar soil is not acting dusty, but is lumpy** (differs from findings of previous missions).
  - **Lunar Soil** is a thick layer of regolith, fragmental and unconsolidated rock material, covers the entire lunar surface.
    - ✓ Are not sorted in any way, by size, shape, or chemistry**.**
    - ✓ Contains no **organic matter.**
    - ✓ Soil grains tend to be sharp with fresh fractured surfaces.
    - ✓ **Components of Lunar Regolith:** Made up of rock chips, mineral fragments, impact and volcanic glasses and a peculiar component **only found on the Moon** called "**agglutinates**".

Related Development
- ISRO successfully **returned the Chandrayaan-3's Propulsion Module** from lunar orbit to Earth's orbit (first instance).
- It was ISRO's first **demonstration of a gravity assist flyby around another celestial body**.

Previous Lunar Missions of India

	Chandrayaan 1 (2008)	Chandrayaan 2 (2019)
Objective	• To **prepare a three-dimensional atlas** of both near and far side of the moon.	• **Widened the scientific objectives** of Chandrayaan-1 by way of **soft landing on the Moon**.
Key Findings	• **Detected water in vapour form** in trace amounts and also **discovered water ice in the North polar region** of the Moon. ○ High-energy electrons from the Earth may be forming water on the Moon. • Confirmed **Ocean Magma Hypothesis**. • **Detected x-ray signals during weak solar flares**. • Detected **new spinel-rich rocks.**	• **Detected hydroxyl radical** (OH) and the **water molecule (H2O) separately**. • Finding **water signatures at all latitudes** on the surface of the moon. • Observations related to the **distribution of Argon-40** in lunar exosphere. • **Detected minor elements** – chromium and manganese on lunar surface. • Collected **information about Solar flares**

3.1.2. CHANDRAYAAN SOFT LANDING

Why in the News?

Chandrayaan-3 lander accomplished a '**soft landing**' on the Moon's South Pole.

More about news

- **Shiv Shakti Point is the spot where** the **Vikram** lander made a soft landing.
- Crashing point of **Chandrayaan-2 lander** would be known as **Tiranga Point**.

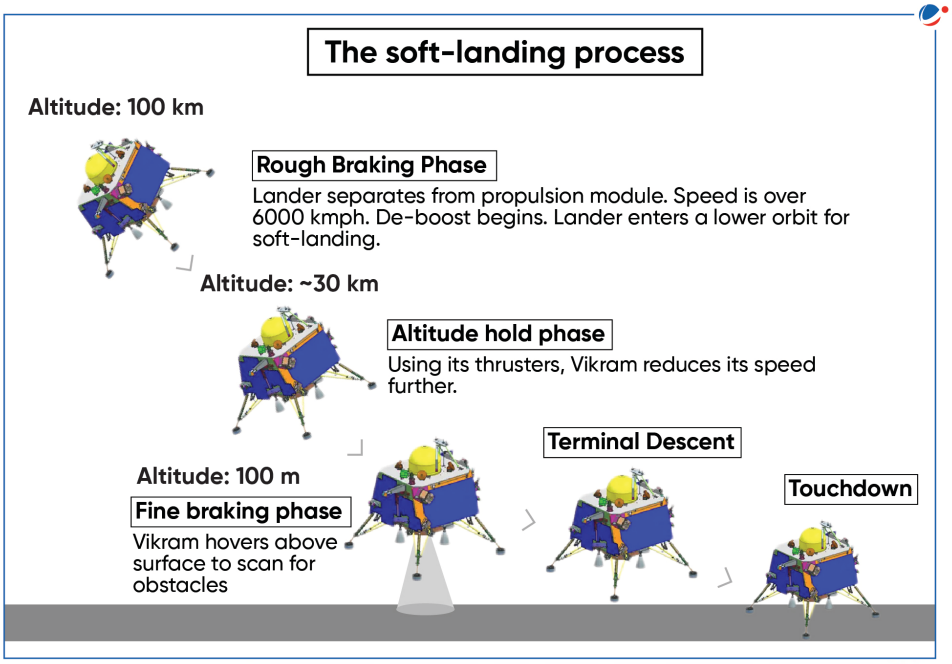
- **August 23**, the day the Chandrayaan-3 lander touched down on the lunar surface, **would be celebrated as 'National Space Day'**.
- Became **world's first mission** to **soft-land** near **lunar South Pole**.
- **Fourth country to soft land on moon**, after US, Russia, and China.
  - Recently, Japan became fifth country to land its **Smart Lander for Investigating Moon (SLIM)** on Moon.

Soft Landing vs Hard-landing

- **Soft-landing entails a controlled descent**, ensuring the craft's safe and gradual touchdown.
  - Soft-landings become indispensable in crewed missions and scenarios where **scientific measurements and tests follow the landing.**
- **Hard-landings (crash landings)** transpire at a higher descent speed.
  - Hard-landings serve a **purpose when the craft's mission is already fulfilled, as seen in instances like aerial surveys.**

Soft-landing challenges

- **Difficult terrain**: Unexpected and sudden terrain changes can lead to altitude sensor errors or software glitches.
- **Distance**: After the lander separates from the propulsion module and enters a 100 km x 30 km orbit (farthest it will be from the moon is 100 km, and the closest is 30 km).
- **Speed**: Soft-landing a lunar module means going from the screaming speeds of over 6,000 km/h to zero. As moon has no atmosphere, the parachutes cannot slow the descent.
- **Lunar Dust**: can obscure the camera lens and trigger faulty readings.

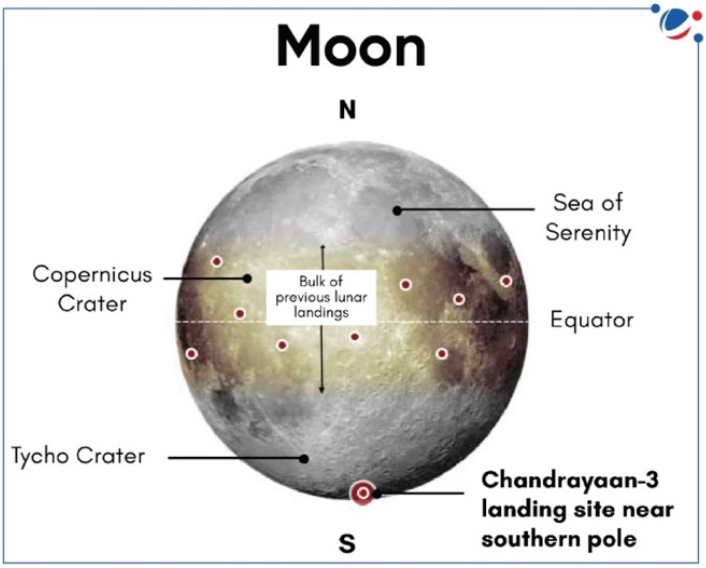


How Chandrayaan-3 tackled challenges?

- **Larger landing site** from earlier 500m x 500m to four km by 2.5 km.
- **Increased landing velocity**: Vertical velocity increased from 2 m/sec to 3 m/sec.
- **Improved thrusters**: While its predecessor had five thrusters, this mission's lander has only four.
- **Other improvements** like larger solar panels, rigorous testing, increased fuel-carrying capacity, etc.

Why South Pole of the Moon?

- **Moon's south pole has certain advantages** which includes:
  - **Craters have been untouched by sunlight** for billions of years**.**
  - **Permanently shadowed craters** are estimated to **hold enough water.**



- **Positional advantages for future space exploration**.
- **Untapped source** of essential resources (such as **mercury, and silver)**.

- **All previous spacecraft** to have landed on Moon **have landed in equatorial region**.
  - It is **easier and safer to land** near equator.
  - **Terrain and temperature are more hospitable** and conducive.
  - **Sunlight is present in abundance**.

3.1.3. TIDAL LOCKING

Why in the News?

ISRO postponed the plans to revive the lander Vikram and rover Pragyan **which were put to sleep to survive the lunar night.**

More about News

- The Chandrayaan-3 mission is **solar-powered** and its landing **coincided with the daylight period on the Moon**.
  - **The diurnal temperature range on the Moon is very high,** making it difficult for Chandrayaan-3 Mission's electronics to withstand the extremely low temperatures during the Lunar Night.
  - **Therefore, Lander and rover were** put into hibernation a little **before lunar sunset.**
- **Temperature on the Moon**
  - **Daytime temperature** near the lunar equator is **250 degrees Fahrenheit** (120° C).
  - While **night time temperatures** is **-208 degrees Fahrenheit** (-130° C).
  - **High diurnal temperature range** is caused by
    - ✓ **Absence** of an **atmosphere**
    - ✓ **Tidal locking** of the Moon with the Earth.

About Lunar Day

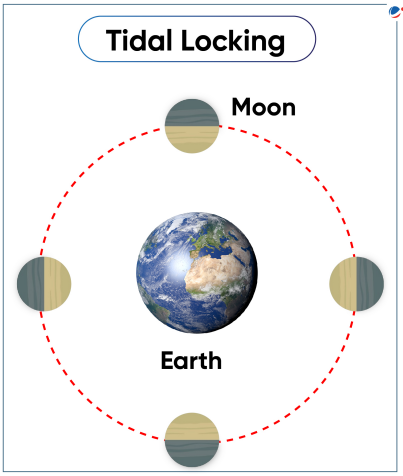
- A mean solar day on the Moon i.e. **Lunar Day** is the time the **moon takes to complete one rotation on its axis** with respect to the **Sun**.
- One mean solar day on the Moon is **29.5 Earth days** (one mean solar day on Earth is 24 hrs).
- **Daylight** on the Moon or **Lunar day** last **approximately** for **two weeks**, followed by **two weeks of lunar night**.

Impact of Lunar night

- **Shapes Moon missions:** Extremely low temperature makes it **difficult to keep spacecraft systems alive.**
- **Aid in Research:** Since Moon does not have atmosphere to distribute heat.
- **Everything has its own unique amount of time** to heat up and cool down.

About Tidal Locking

- **Synchronization** between the Moon's **rotation** around its axis (with respect to the Sun) and its **orbit** around the **Earth.**
- Happens due to the **gravitational force exerted by both the moon and the earth on each other.**
- **Effects of Tidal locking**
  - **Only one side of moon remains visible from the earth.** This creates a scenario where moon gets divided **into two parts** i.e.:
    - ✓ **Near Side of moon: Visible from Earth** (about 60%)**.**
      - **Relatively smoother, thinner crust** and **has large volcanic plains**.
    - ✓ **Far side:** Never visible from the Earth (about 40%).
      - **Illuminated in sunlight during the 'new moon' phase** (when the moon is invisible from Earth).
      - Has **huge craters** which **make it non-conducive for space mission.**
      - **China's Chang é-4 lander is the only** one to have successfully **landed.**
  - **Distortion of shape:** The **gravitational force** that is exerted is always **stronger on the sides facing each other.**
  - This force causes the bodies to **stretch and distort, alternating high and low ocean tides etc.**
  - **Slow rotation:** Tidal torque **slows down the spin of the planet.**



3.2. ADITYA-L1

Why in the News?

ISRO has successfully placed **India's first space-based observatory-class solar mission** in halo orbit at Lagrange Point L1 to study the Sun.

About Aditya – L1

- **Launch vehicle: PSLV C57**
- **Scientific objectives**
  - Study of **Solar upper atmospheric (chromosphere and corona) dynamics**.
  - Study of **chromospheric and coronal heating**, physics of the partially ionized plasma, initiation of the **coronal mass ejections (CMEs)**, and **solar flares.**
  - Observe the **in-situ particle and plasma environment**.
  - **Study drivers for space weather** (origin, composition and dynamics of solar wind).
- **Aditya – L1 carries 7 payloads** (5 by ISRO and 2 by Indian Academic institutes)
  - **Remote sensing payloads**
    - ✓ Visible Emission Line Coronograph (VELC)
    - ✓ Solar Ultraviolet Imaging Telescope (SUIT)
    - ✓ Solar Low Energy X-ray Spectrometer (SoLEXS)
    - ✓ High Energy L1 Orbiting X-ray Spectrometer (HEL1OS)
  - **In-situ payloads**
    - ✓ Aditya Solar wind Particle Experiment (ASPEX)
    - ✓ Plasma Analyser Package For Aditya (PAPA)
    - ✓ Advanced Tri-axial High Resolution Digital Magnetometers

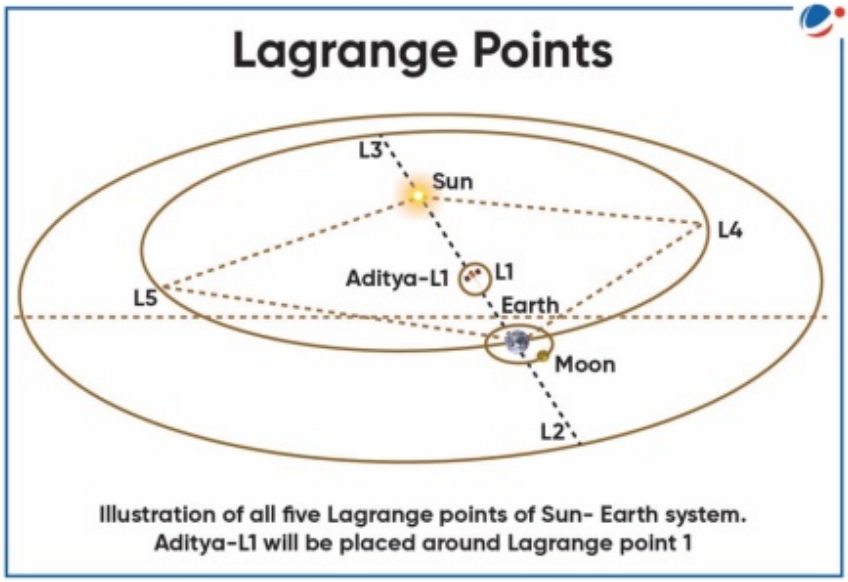
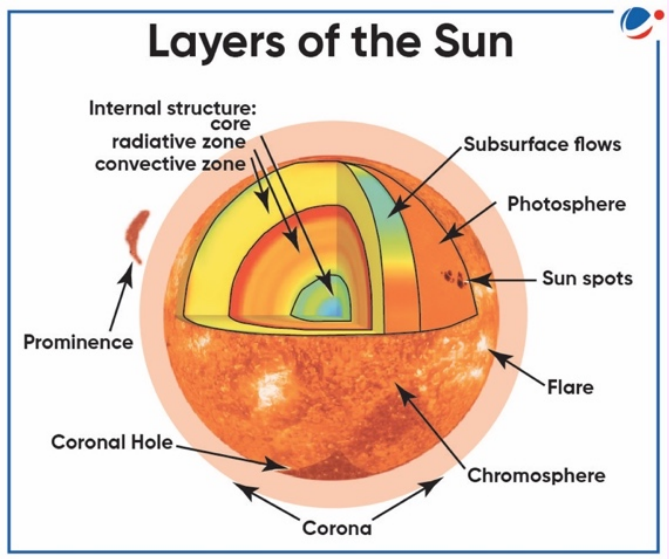


Illustration of all five Lagrange points of Sun- Earth system. Aditya-L1 will be placed around Lagrange point 1

- **Uniqueness of the mission**
  - First time spatially resolved solar disk in the near UV band.
  - **On-board intelligence to detect CMEs and solar flares** for optimised observations and data volume.
  - **Directional** and **energy anisotropy of solar wind** using multi-direction observations.

About Lagrangian points

- Lagrange Points are the **positions in space** where a **small object tends to stay**. **Gravitational pull of the two large bodies equals** the necessary **centripetal force**.
  - **For two body gravitational systems**, there are **total of five Lagrange points** denoted as L1, L2, L3, L4 and L5.
  - Of these **five Lagrange points**, three **(L1, L2, L3) are unstable** and two **(L4, L5) are stable**.
- **Significance**: Spacecraft remain at these positions with **reduced fuel consumption.**
  - **L1** gives advantage of **continuous observation of the Sun.**
- **Other key information**:
  - NASA-ESA's joint **Solar and Heliospheric Observatory Satellite (SOHO) mission** is **placed near L1 point** while NASA's **James Webb Space Telescope is placed around L2 point**.
- **Other solar missions**: **Parker Solar Probe** (NASA), **Solar and Heliospheric Observatory (**European Space Agency**), Kuafu-1 solar probe** (China) etc.



Photosphere: Deepest layer of the Sun that one can observe directly and it reaches from the surface visible at the center of the solar disk to about 400 km above that. • The temperature in **the photosphere varies between about 6500 K** at the bottom and 4000 K at the top.	**Coronal holes: Dark areas in the solar corona in extreme ultraviolet** (EUV) and soft x-ray solar images. • They appear **dark because they are cooler**, less dense regions than the surrounding plasma and are regions of open, unipolar magnetic fields. • Coronal **holes can develop at any time and location on the Sun**, but are more common and persistent during the years around solar minimum.
Chromosphere: Layer in the Sun between about 400 km and 2100 km above the solar surface (the photosphere). • The temperature in the **chromosphere varies between about 4000 K** at the bottom and 8000 K at the top.	**Sunspots:** Like coronal holes, are darker and cooler than the rest of the sun's disk, but they form in the lower layer of the sun's atmosphere, the photosphere. • Unlike coronal holes, **sunspots are areas where the sun's magnetic field is extremely strong and the magnetic lines twisted.**
Transition Region: A very narrow (100 km) layer between the chromosphere and the corona where the temperature rises abruptly from about 8000 to about 500,000 K.	**Solar prominence:** Large, bright feature extending outward from the Sun's surface. • Prominences are **anchored to the Sun's surface in the photosphere,** and extend outwards into the Sun's hot outer atmosphere, called the corona. • A prominence **forms over timescales of about a day.**
Corona: Outermost layer of the Sun, starting at about 2100 km above the solar surface (the photosphere). • The temperature in the corona is 500,000 K or more, up to a few million K. • The corona **cannot be seen with the naked eye except during a total solar eclipse**, or with the use of a coronagraph. • The corona **does not have an upper limit.**	**Solar flares**: **Giant explosions on the sun** that send energy, light, and high-speed particles into space. • These flares are often associated with **coronal mass ejections (CMEs).** • **CME contains particle radiation** (mostly protons and electrons) and powerful magnetic fields. • **Impacts:** Disturb **operations of space-dependent services** like GPS, radio, and satellite communications, **damage satellite electronics**, disruption of power grids, expose astronauts to **increased levels of radiation**, Orbits of the satellites could be disturbed etc.

Related Developments
Solar wind

- Solar Orbiter of **ESA** (European Space Agency) **and NASA** have **detected numerous relatively small jets of charged particles** (called picoflare jets) that could be a **major source to sustain solar wind.**
  - Picoflare jets are **expelled intermittently from structures on corona** (outermost layer of sun's atmosphere) **called coronal holes**.
- Solar wind **continuously flows outward from Sun** and consists **mainly of protons and electrons** in a state known **as plasma**.
- While **Earth's magnetosphere deflects most solar activity** carried by solar wind. **Some charged particles seep through** and **cause magnetic disturbances**, classified as either geomagnetic storms or substorms.
  - These **storms can be benign**, as when **displayed in auroral** light shows.

3.3. GAGANYAAN MISSION

Why in the news?

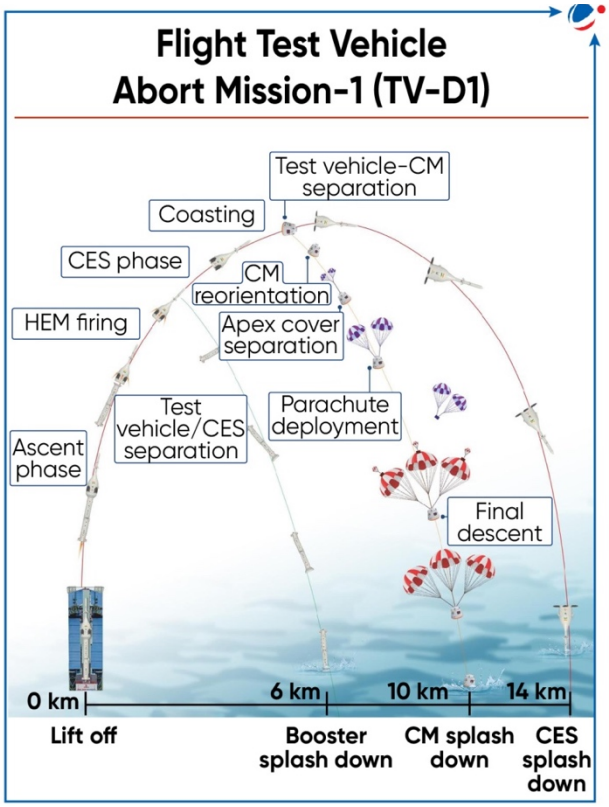
Recently, the **names of astronauts have been announced** for the Gaganyaan mission

More on News

- **Recently, Gaganyaan's first Flight Test Vehicle Abort Mission**-1 (TV-D1) was also successfully executed.
- Flight simulated the abort condition during the ascent trajectory.
- TV-D1 is a **single-stage liquid rocket**.

About Mission Gaganyaan

- Envisages a demonstration of human spaceflight capability.
- A crew of **3 members** to an orbit of **400 km for a 3-day mission** will be launched.
- **Launch Vehicle**: LVM3 (Geosynchronous Satellite Launch Vehicle Mk III).
  - Consists of solid stage, liquid stage and cryogenic stage.
- **Gaganyaan National Advisory Council** has been created.



- ISRO indigenously developed **Environmental Control and Life Support System (ECLSS).**
- **Only US, Russia** and **China** have managed to send **manned missions** to outer space.

Status of the Gaganyaan programme

- **Design of all systems and sub-systems has been completed.**
- Human-rated **L110-G VIKAS engine** has been successfully tested.
  - **VIKAS** (an acronym for Vikram Ambalal Sarabhai) engine is a family of **liquid-fuelled rocket engines.**
- Completed the **Service Module Propulsion System (SMPS)** Test.
- ISRO will carry out a test flight **with a robot, 'Vyommitra'.**

Related Developments
CE-20 Cryogenic Engine

- ISRO tested the **CE-20** Cryogenic engine to be used in "Mission Gaganyaan".
  - Cryogenic engines **use fuels at cryogenic temperatures (-150 to -273 degree C).**

- **Comparatively more powerful t**han solid and liquid propellant engines.
- First cryogenic engine to use a **Gas-generator cycle** using **Liquid Oxygen and Liquid Hydrogen** propellants combination.
- ISRO also tested a **semi-cryogenic engine**.
  - A semi-cryogenic engine uses **refined kerosene instead of liquid hydrogen.** Liquid oxygen is used as an oxidiser.

3.4. NAVIGATION WITH INDIAN CONSTELLATION (NAVIC)

Why in the News?

Chipsets (microchips) for the **Navigation with Indian Constellation (NavIC)** are being manufactured in India by an Indian company for the first time.

More about News

- Supported by the **Ministry of Science & Technology** and **Ministry of Electronics & Information Technology.**
- These are necessary to make a **navigating gadget compatible with NavIC.**
- **Also, a NVS-01** was launched.
  - It is first of the **India's second-generation satellites envisaged for NavIC services.**

About NavIC

- An **independent stand-alone navigation satellite system.**
- Developed by **ISRO.**
- **Satellites: 3 satellites** are in **geostationary orbit** and **4 satellites** placed in **inclined geosynchronous orbit.**
- **Coverage:** Whole of **India's landmass** and up to **1,500 km (930 miles)** from its boundaries.
- Earlier known as **Indian Regional Navigation Satellite System (IRNSS)**.
- Offers **two services** –
  - **Standard Position Service (SPS)** for civilian users.
  - **Restricted Service (RS)** for strategic users.
- **Need for NavIC:** Remove the dependence on **foreign satellite systems (USA's Global Positioning System (GPS)** or strategic location.
- **Applications:** Terrestrial, Aerial, and Marine Navigation; Disaster Management; Precise Timing; Scientific research; tracking, etc.

Advantage of NavIC over GPS

- Provides **better positioning accuracy of 10 meters** compared to **GPS' accuracy of 20 meters**.
- Unlike GPS, NavIC satellites **are much above the Earth's surface**, hence, **lesser signal blockages in Himalayan mountains or on terrestrial surfaces.**

Related Development

GPS Aided GEO Augmented Navigation (GAGAN)

- A **regional Satellite Based Augmentation System (SBAS).**
- A collaboration of **Airports Authority of India (AAI) and ISRO.**
- Goal is to **provide a navigation system to assist aircraft in accurate landing over the Indian airspace** and in the adjoining area and applicable to safety-to-life civil operations.
- GAGAN covers **the area from Africa to Australia** and has expansion capability for seamless navigation services across the region.
- The **first SBAS in the world which has been certified for approach with vertical guidance operating** in the equatorial ionospheric region.
- One essential component of the GAGAN project is the **study of the ionospheric behaviour over the Indian region.**
- Benefits to sectors like **aviation**, **transportation, railways, surveying, maritime, highways, telecom industry, and security agencies.**
- India is the **third country in the world which has such precision approach capabilities.**

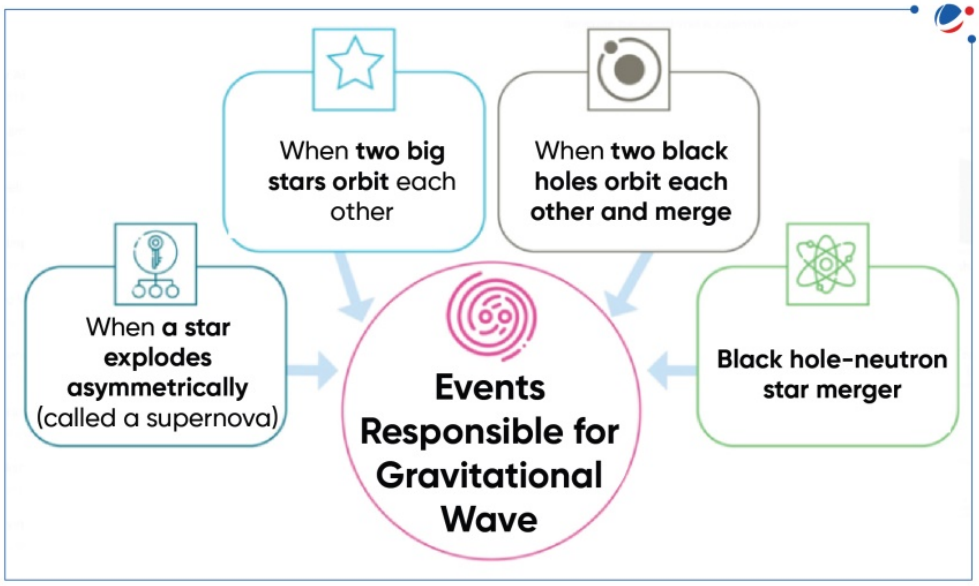
SAGAR SAMPARK

- **Indigenous Differential Global Navigation Satellite System (DGNSS) – "SAGAR SAMPARK" was inaugurated** by the Ministry of Ports, Shipping and Waterways (MoPSW).
- **DGNSS** is a terrestrial-based **enhancement system** which **corrects errors and inaccuracies in** GNSS.
  - GNSS refers to a **constellation of satellites.**
  - **It provides signals from space** that transmit positioning and timing data **to GNSS receivers** to have Global coverage.
  - **Major GNSS are: Global Positioning System GPS** (USA), **GLObalnaya NAvigatsionnaya Sputnikovaya Sistema GLONASS** (Russia), **Galileo** (Europe), and **BeiDou** (China).

3.5. GRAVITATIONAL WAVES

Why in the News?

Scientists recently unveiled evidence that **gravitational waves are permeating the universe at low frequencies** - creating a **cosmic background hum.**



About Gravitational Waves (GW)

- **Ripples in the fabric of spacetime** caused by the most **energetic events** in the cosmos, such as **black hole mergers and neutron star collisions**.
- Most powerful gravitational waves are created when **objects move at very high speeds.**
- Albert Einstein predicted the **existence of gravitational waves in 1916** in his **General Theory of Relativity.**
- **First detected in 2015** with the help of **Laser Interferometer Gravitational Observatory (LIGO) detectors.**
- **Study of Gravitational Waves helps:**
  - Helps scientists **expand their knowledge about the nature** and evolution of the universe.
  - To answer mysteries about the **nature of merging supermassive black holes**, etc.

Higher and lower frequency gravitational waves

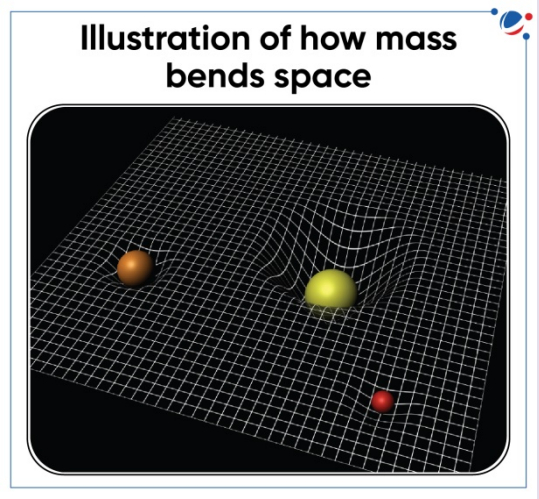
- **Higher-frequency** gravitational waves **come from smaller pairs of black holes**.
- **While the lower-frequency waves** are thought to be generated **by huge black holes.**

Related Development and Concepts
About Gravity and Space-time

- **Einstein** in his General Theory of Relativity postulated that **Space and time were not independent entities** but had to be woven together as space-time.
- Einstein proposed that **gravitational attraction was a result of the bending of the fabric of space-time** by the equivalent of a heavy object.
- **The greater the mass** of an object the **more extreme the warping of space** it causes, so a **star warps space-time more than a planet, and a black hole warp it more than a star.**
- Einstein said the **Sun, the Earth and all other bodies formed similar curvatures around them**, and this was the reason for smaller objects getting pulled towards them.
- But since the **Earth, sun and everything else are also moving**, the **curvature around them moves too**. This **creates ripples in space-time**, just like a moving boat in water creates ripples (**gravitational waves)**.

Gravitational lensing

- It is an **effect on light from a background source that arises as a result of the curvature of spacetime,** the three dimensions of space and time united into a single entity, caused by mass.
- An important consequence of this **lensing distortion is magnification,** allowing us to observe objects that would otherwise be too far away and too faint to be seen.
- **Einstein Cross** is a specific case of Gravitational Lensing.



About Giant Metrewave Radio Telescope (GMRT)

- An instrument for **studying astrophysical phenomena, at low radio frequencies** (40 to 1450 MHz).
- **Operated by National Centre of Radio Astrophysics** (NCRA) Pune.
- Part of **Tata Institute of Fundamental Research.**

Pulsars

- **Pulsars are Distant rapidly-rotating neutron stars** that emit pulses of radiation, observed from the Earth as bright flashes of light.
    - These **bursts take place at extremely precise intervals**, and therefore scientists use pulsars as **'cosmic clocks'**.
- They are **highly magnetized, and rotating at enormous speeds**.
- Pulsars emit **a beam of electromagnetic radiation** from their magnetic poles while rotating.
- **'Period' of the pulsar** refers to time when pulsar appears to 'switch off' at points when the **light is facing away from Earth.**

3.5.1. LIGO-INDIA PROJECT

Why in news?

Union Cabinet has approved the **Laser Interferometer Gravitational-Wave Observatory, or LIGO, project** to build an advanced gravitational-wave detector.

About the project

- LIGO - India is a planned **advanced gravitational-wave observatory**, part of the worldwide network.
    - Observatory will be **the third of its kind**.
    - **Exact specifications of the twin LIGO, in Louisiana and Washington** in the U.S.
    - **A fourth detector in Kagra, Japan, is in the pipeline**.
- **Location:** Hingoli district in Maharashtra.
- **Funding:** Department of Atomic Energy (DAE) and the Department of Science and Technology (DST).
- **Capacity**: **Collaborative project** between a consortium of Indian research institutions and the LIGO Laboratory in USA.

Related Development

Einstein Telescope

- The Einstein Telescope (ET) Collaboration has entered into an agreement with CERN (European Organization for Nuclear Research) for the design of the detector's vacuum system.
- **ET** is a proposed underground infrastructure (at least 200 m beneath the surface) **to host a third-generation, gravitational-wave observatory.**

Laser Interferometer Space Antenna (LISA)

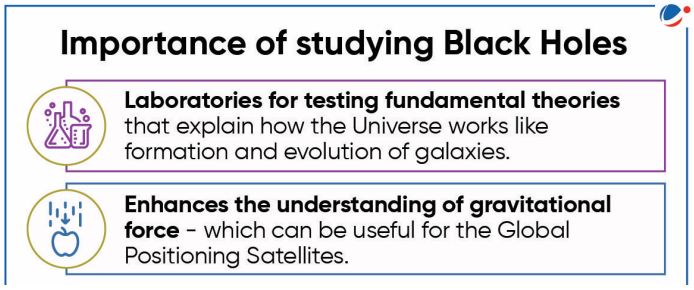
- LISA is a space-based **gravitational wave observatory** building on the success of **LISA Pathfinder**.
- Led by ESA, the LISA mission is a collaboration of ESA, NASA, and an international consortium of scientists.

- The **evolved Laser Interfermoter Space Antenna (eLISA)** is also a mission aiming at exploring the Gravitational Universe from space for the first time.
  - It consists of a "**Mother" and two "Daughter" spacecrafts.**

3.6. BLACK HOLES & TIME DILATION

Why in the News?

Scientists recently observed a class of **black holes** (quasars) demonstrating time dilation in the early universe.

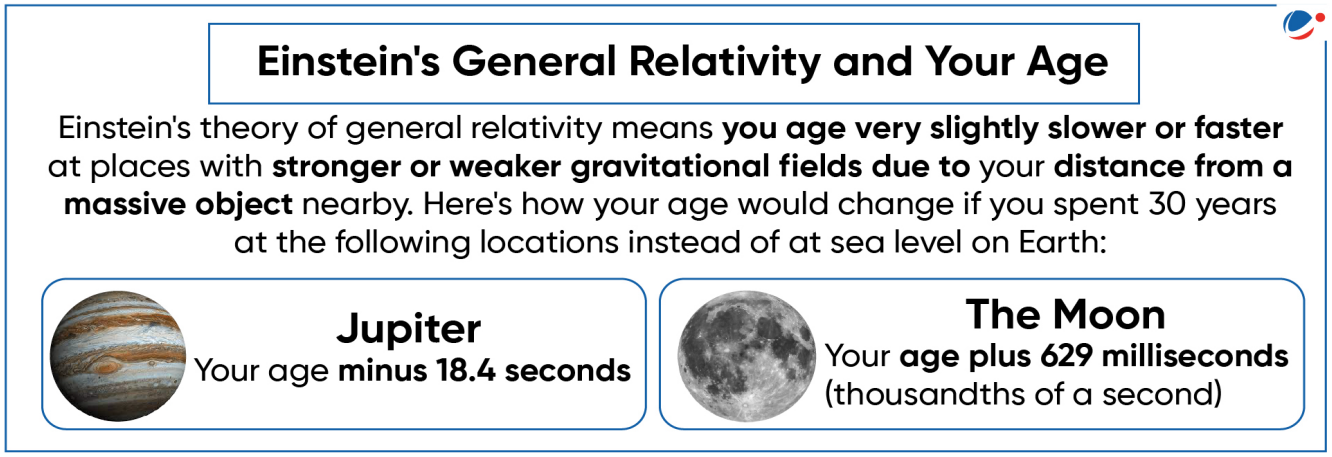


More about News

- This time dilation illustrates that during that period, **time passed at only about a fifth of the current rate.**
- Quasar is **extremely active and luminous type of active galactic nucleus (AGN).**
  - Sometimes they **tremendously active supermassive black holes** residing at centres of galaxies.
  - There are **no quasars near Milky Way.**

About Time Dilation

- **Means time passes** at different **rates** for **different observers**.
  - It **depends on their relative motion** or positions **in a gravitational field.**
- **Einstein's Theory of relativity** also proposed about this effect of Time Dilation.
- **Occurrence**:
  - **Objects with a lot of mass** create a strong gravitational field.
  - **Stronger the gravity, the more spacetime curves**, and the slower time itself proceeds.



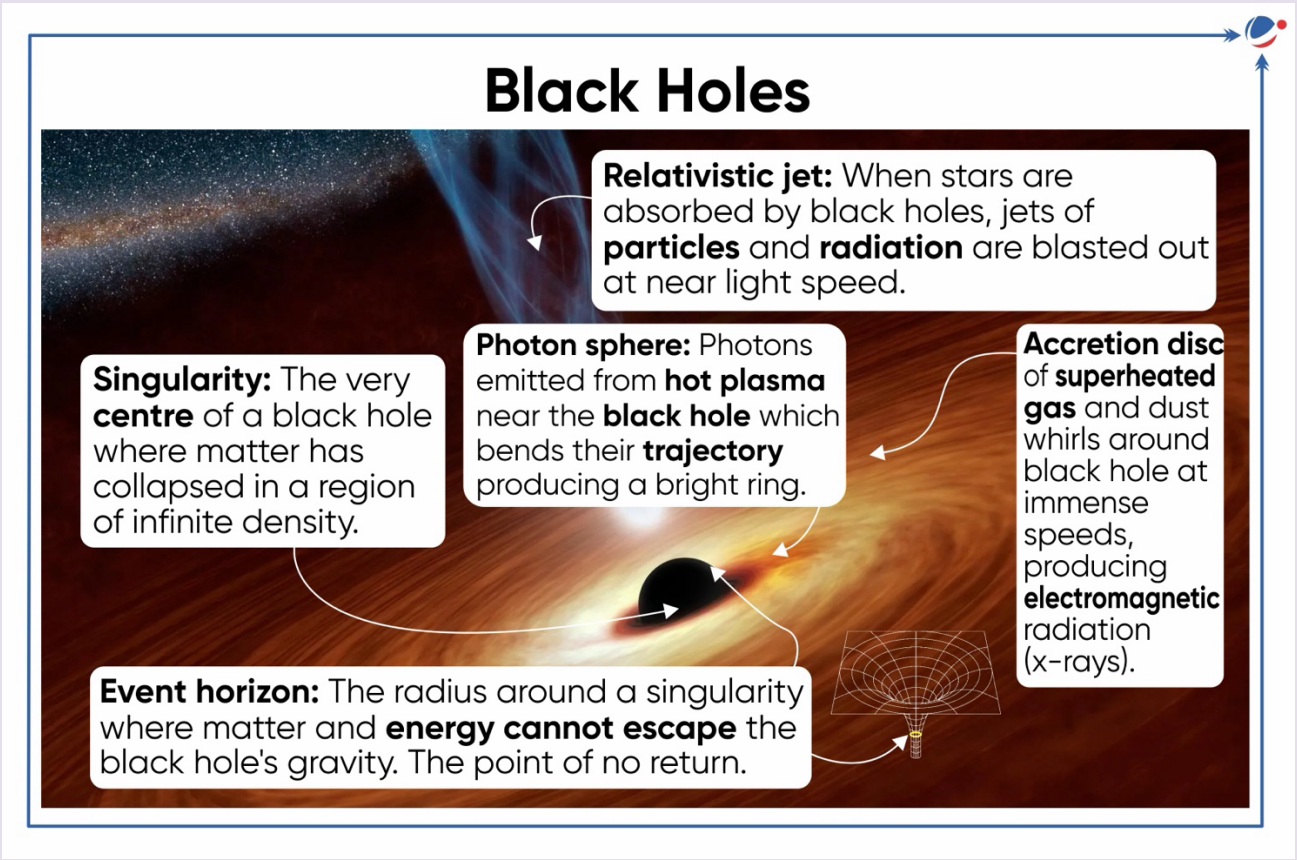
About Black Holes

- It is a cosmic body in space where **gravity pulls so much that even light cannot escape.** In this, **matter is squeezed into a tiny space.**
- **Formation:** Most black holes form **from the remnants of a large star that dies in a supernova explosion.**
- **Other Features: Invisible** and can be **big or small.**
- **Cannot be directly observed** (do not emit or radiate light, or any other electromagnetic waves)
  - But the **area just outside the boundary of the black hole** (Event Horizon), **emits all kinds of radiation, including even visible light.**

Types of Black Holes			
Primordial Black Holes • **Formed in the first second** after the birth of the universe.	**Stellar Black Holes** • Formed when **centre of a very big star falls** upon itself or collapses. • When this happens, it **causes a supernova.**	**Intermediate Black Holes** • Range from around **one hundred to hundreds of thousands of times the Sun's mass**.	**Supermassive Black Holes** • **Almost every large galaxy** has a supermassive black hole at its center.

Basic Parts of Black Holes

- **The Schwarzschild Radius:** This is the event horizon's radius at which the escape velocity is equal to the speed of light.
- **The Ergosphere:** If the black hole is rotating, then as it spins, its mass causes the space time around the black hole to rotate as well.



3.7. DARK MATTER MAP

Why in the News?

Astronomers have made the most **detailed map of dark matter** showing that both the 'lumpiness' (piece of a solid substance, usually with no particular shape) of the universe and the rate at which the universe is growing.

More about News

- They have created a map by using **the microwave detector of the Atacama Cosmology Telescope (ACT).**
- Astronomers were observing by ACT whether **Einstein's predictions in his theory are correct** regarding the **expansion of the Universe**.
- They also observed the sanctity of the **standard model of cosmology (SMC)**.
  - As per SMC model, there is **a fixed and precise sequence of events** that **followed the Big Bang**.

Observation and Outcome Made by Astronomers

- **Invisible world**: Features of the **invisible world** (dark matter and energy) were observed which are hundreds of millions of light years across.
- **Cosmic Microwave Background (CMB) radiation**: **Gravitational pull** of large, heavy structures including dark matter warps the **CMB radiation** on its 14-billion-year journey to Earth.
  - **CMB** or **fossil radiation** is the **cooled remnant** of the **first light (or leftover of the Big Bang)**.
  - The CMB light **gets deflected** by **dark matter.**

Big Bang Model

- It is the only model that is able to **explain the existence of the Cosmic Microwave Background (CMB).**
- According to it, the **emergence of the universe from a state of extremely high temperature and density**—the so-called big bang that **occurred 13.8 billion years ago.**
- It is based **on two assumptions:**
  - **Albert Einstein's general theory of relativity** correctly describes the gravitational interaction of all matter.
  - **Cosmological principle**, states that an observer's view of the universe depends neither on the direction in which he looks nor on his location.

- **Lumpiness**: Measurements showed that the 'lumpiness' of the universe is of the **exact right size as per SMC.**
- **Expansion**: Rate at which it is growing is just what was expected from our SMC based on Einstein's theory.
- **Gravitational lensing**: It was observed while recording the movement of the CMB.

Composition of the Universe

Dark Matter

- Unlike **normal matter**, dark matter **does not interact** with **electromagnetic force**.
- Researchers **have been able** to infer the **existence of dark matter only** from the **gravitational effect.**
- It seems to outweigh **visible matter roughly six to one**, making up about **27%** of the universe.
- Astronomer **Fritz Zwicky** first used the term "**dark matter**" in the 1930s.

Dark Energy

- It makes up approximately **68%** of the **universe** and appears to be **associated** with the vacuum in space.
- It is **distributed** evenly throughout the **universe**.

Normal Matter

- It makes **up 5%** of the Universe.
- It **includes** Earth, the sun, other stars, and galaxies.

3.8. JAMES WEBB SPACE TELESCOPE (JWST)

Why in the news?

Recently, JSWT took an image of the **dense heart of Milky Way Galaxy and revealed its new features**.

More about News

- Star-forming region called **Sagittarius C** is a supermassive black hole at the **Milky Way Galaxy's** centre.
- It **included protostars** - stars that are still forming and gaining mass.

Findings of JWST

- **Questioning the standard model of cosmology:** Discovered the existence of **fully formed galaxies** far earlier than should have been possible according to the **standard model of cosmology**
- **Low-mass galaxies: Galaxy's brightness** is typically **determined by its mass** but **the findings** suggest that **less massive galaxies can glow** bright.
- **Studying star formation: Star formation unfolded differently** in galaxies in the first few hundred million years **after the Big Bang event** than it does in large galaxies like our Milky Way.

About James Webb Space Telescope

- **James Webb Space Telescope** launched in 2021, is a joint project of **NASA, the European Space Agency (ESA) and the Canadian Space Agency.**
- JWST is being considered as **successor of Hubble Space Telescope (HST).**

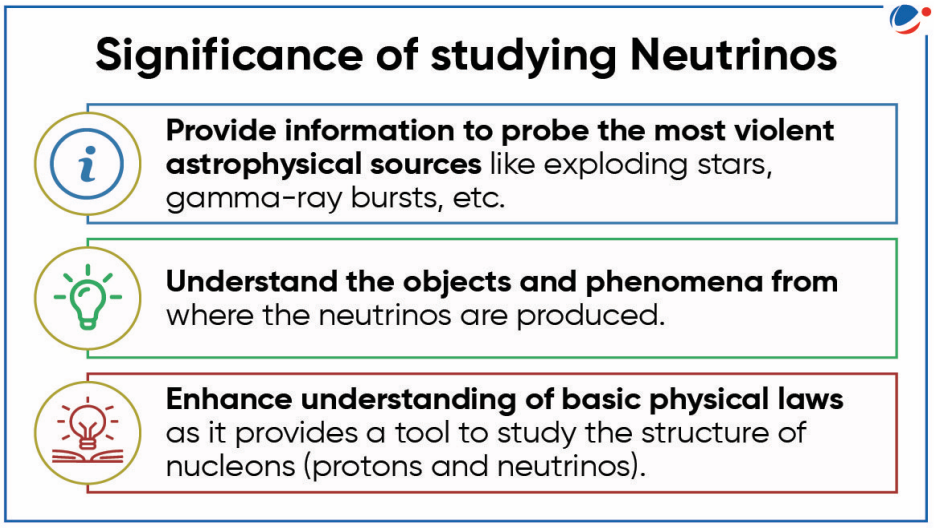
Related Concept
Hubble constant

- In 1929, **Edwin Hubble provided first mathematical description** of **universe's expansion.**
- It is referred as the **Hubble constant.**
- **Hubble constant is calculated by:**
  - Comparing observed **brightness of a supernova**, the largest explosion of a star that takes place in space
  - Analysing changes to **cosmic microwave background** (CMB), radiation left over from big bang event.
  - Using **Gravitational waves.**

3.9. NEUTRINO PARTICLES

Why in the news?

For the first time, scientists have seen neutrinos originating from the central disk of the Milky Way.



About Neutrinos

- **Fundamental particles** (but not part of the atom), **like electrons**, so they **can't be broken down** into smaller parts.
- **Key characteristics:**
  - **Very tiny mass,** has **no charge** and **half spin.**
  - **Travel at almost the speed of light** and **in straight lines** from their source.
  - **Rarely interact** with other matter (referred as **ghost particle**).
  - **Outnumber** all the **atoms in the universe**.
  - **Only** affected by **gravity and the weak force**.
  - **3 types** – electron neutrino, tau neutrino and muon neutrino.
    - ✓ They can change from one type to another as they travel. This process is called **neutrino oscillation.**
- **Sources of Neutrinos:**
  - When cosmic rays collide with interstellar matter.
  - **Produced by stars like the Sun**, exploding stars, supernovas, etc.
  - **On Earth**, neutrinos are produced **when unstable atoms decay**.
    - ✓ **Even a banana emits neutrinos**—due to **natural radioactivity of the potassium**.
- **Proposed India-based Neutrino Observatory (INO)** will study atmospheric neutrinos only.
  - It is **multi-institutional effort** aimed at building a world-class underground laboratory with a rock cover of approx. 1200 m for non-accelerator based high energy and nuclear physics research in India.
  - It is **jointly funded by Dept. of Atomic Energy (DAE) and the Dept. of Science and Technology (DST)**.
  - **Iron Calorimeter (ICAL) detector** will be used for studying neutrinos.
  - It will be located in **Bodi West Hills (BWH) region** in Theni district of **Tamil Nadu.**
  - It is located here **due to proximity to equator.**

Atmospheric neutrinos

- **Produced around 15 kms** above Earth's surface.
- They are **produced from cosmic rays** which consist of protons and heavy nuclei.
- These collide with atmospheric molecules such as Nitrogen to give off **pions and muons which further decay to produce neutrinos.**

3.10. JUPITER ICY MOONS EXPLORER (JUICE) MISSION

Why in the News?

European Space Agency (ESA) has launched JUICE from Europe's spaceport French Guiana on to Jupiter and its moons through Ariane-5.

About JUICE Mission

- **Objectives:** Study Jupiter and its three **large ocean-bearing** moons – **Ganymede, Callisto and Europa**.
  - Observe **moons' weather**, **magnetic field**, **gravitational pull** and other elements.
- **Spacecraft**: Record **85 square metres of solar panels**.
- **Payload**: Includes **GALA** (GAnymede Laser Altimeter), **MAJIS** (Moons and Jupiter Imaging Spectrometer), **UVS** (UV imaging Spectrograph) etc.
- It will use **double gravity assist**, for the **first time,** from Earth and Moon to propel itself towards Jupiter.

Major Space Missions to Jupiter

Mission	By	Year
Pioneer 10	NASA	1972
Voyager 1 and 2	NASA	1977
Galileo (first to enter Jupiter's orbit)	NASA	1989
Ulysses	NASA and ESA	1990
Juno	NASA	2011
Europa Clipper	NASA	Expected 2024

About Jupiter

- Fifth from the Sun and **largest planet** in the solar system.
- One of the **Jovian planets** (others are Saturn, Uranus and Neptune).
  - Jovian Planets do not have solid surfaces, instead, it is composed **primarily of hydrogen and helium,** with traces of methane, ammonia, water, and other gases in their atmospheres.
- **2nd highest number of moons (95)** after Saturn (146 moons).
- Has a **faint ring system.**

3.11. ASTEROIDS

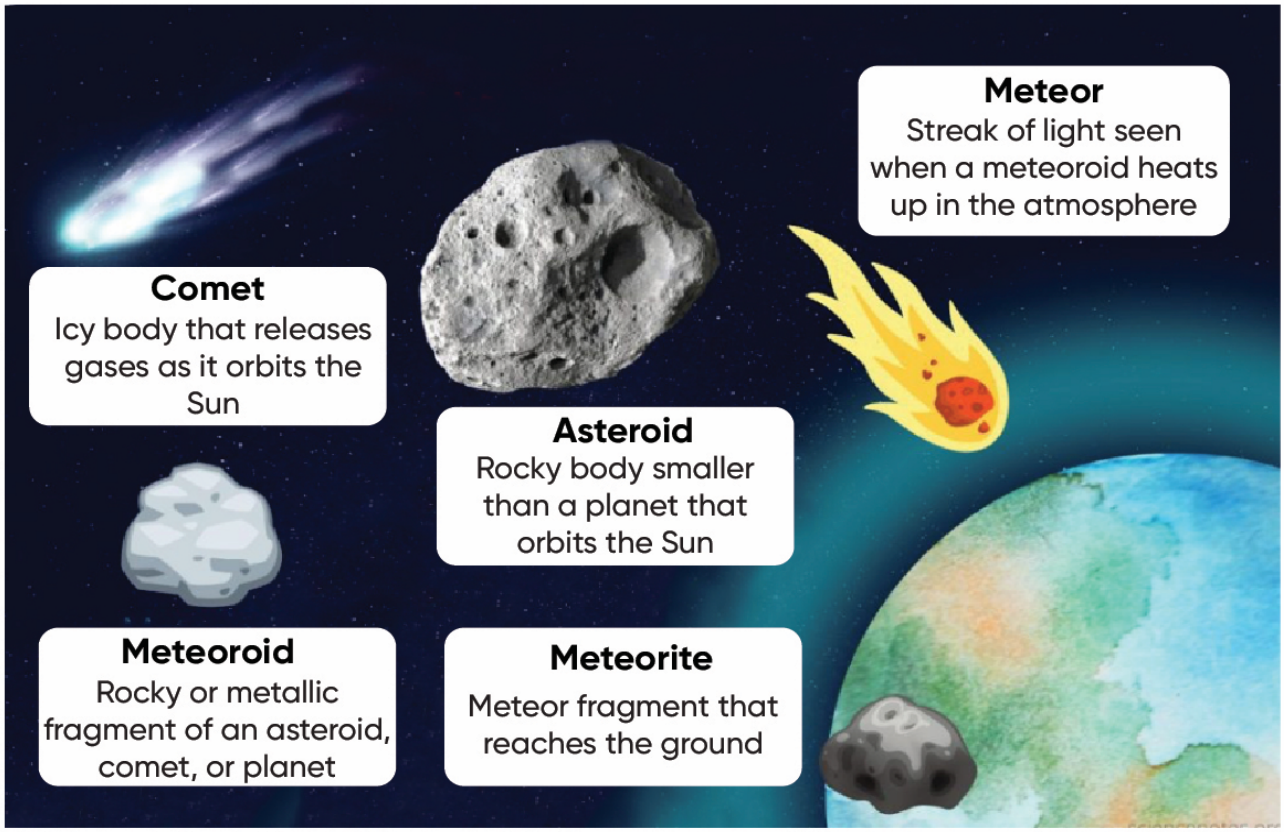
Why in the news?

NASA's **OSIRIS-REx mission** brought the sample from carbon-rich asteroid Bennu back to Earth.

About OSIRIS - REx's mission

- **OSIRIS-REx is an acronym for:** Origins, Spectral Interpretation, Resource Identification, and Security - Regolith Explorer.
- **Goal of the mission: Collect samples** from **asteroid Bennu** and deliver them to Earth.
  - Bennu is small near Earth **carbon rich asteroid.**
- **New Journey**: OSIRIS-REx will continue on to **a new mission to asteroid Apophis.**
  - Hence, renamed as **OSIRIS-APEX (OSIRIS-Apophis Explorer).**

Asteroids and related bodies



Classes of Asteroids

- **Main Asteroid Belt:** Between Mars and Jupiter
- **Trojans:** Share an orbit with a larger planet.
  - They are remnants of our early solar system.
  - NASA's Lucy mission is the first spacecraft launched to explore the Trojan asteroids.
- **Near-Earth Asteroids:** Pass close to the Earth. Also known as **Earth-crossers.**

How does Asteroid exploration contribute to Astronomy?

- **Insight on formation of Solar System**: Understand the conditions and materials present at that time.
- **Origin of Life**: Provides insights into the chemical and organic compounds.
- **Planetary Defence**: Understanding the **composition and structure** of asteroids is crucial for creating **planetary defence efforts** for the future**.**
- **Space Exploration Technology**: Demonstrated **advanced technology** in spacecraft **design, navigation,** and **sample collection**.
- **Other: Resource Utilization**, promoting international cooperation etc.

3.12. OUTER SPACE GOVERNANCE

Why in the News?

The United Nations (UN) has recently released a policy brief titled **For All Humanity — The Future of Outer Space Governance.**

Existing governance framework

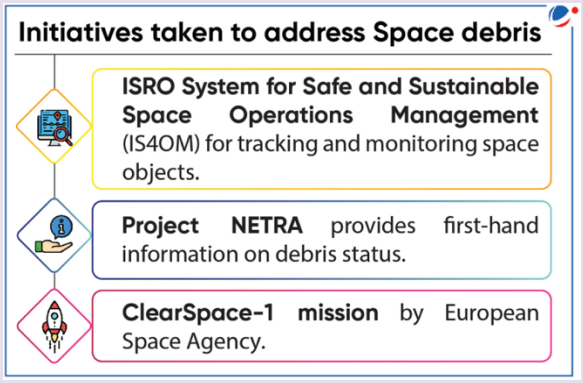
- In **1958, United Nation Committee on the Peaceful Uses of Outer Space (UN COPUOS)** was established.

- Governs the exploration and use of space for the benefit of all humanity.
- Supported **by the United Nations Office for Outer Space Affairs (UNOOSA).**
- **Five international space treaties:**
  - **Outer Space Treaty 1967:** Treaty on Principles Governing the Activities of States
  - **Rescue Agreement 1968:** Agreement on the Rescue of Astronauts, the Return of Astronauts, and the Return of Objects Launched into Outer Space**.**
  - **Liability Convention 1972:** Convention on International Liability for Damage Caused by Space Objects.
  - **Registration Convention 1976:** Convention on Registration of Objects Launched into Outer Space.
  - **Moon Agreement 1979:** Agreement Governing the Activities of States on the Moon and Other Celestial Bodies.
- India is a **signatory to all five of these treaties but has ratified only four (except Moon Agreement).**.

Related Concepts

Space Debris

- Indian Space Research Organisation (ISRO) rocket debris has been found on **Australian shore.**
- **About Space Debris**
  - Space debris encompasses both **natural (meteoroid) and artificial (man-made) particles.**
  - **Russia, followed by USA, China and France** are top contributor to space debris.
- **Impact of Space debris**
  - **Thousands of discarded launch vehicles** float around in space, **risking collision**.
  - **Large object entering earth can be threat to marine life,** and **a source of pollution.**
- Liability Convention**1972 provides for procedures** for settlement of claims for damages.



Kessler syndrome

- Scenario in which the **density of objects in low Earth orbit (LEO) due to space pollution is numerous**
- This may result in **collisions between objects could cause a cascade in which each collision** generates space debris that **increases the likelihood of further collisions.**
- Proposed by NASA scientist **Donald J. Kessler in 1978.**

3.13. KEY CONCEPT/TERMS IN NEWS

3.13.1. GOLDILOCKS ZONE

- It is also referred as the **habitable zone.**
- It is the area around a star where it is **not too hot** and **not too cold** for liquid water to exist on the surface of **surrounding planets.**

3.13.2. EXOPLANET

- **New Jupiter size exoplanet**, called **TOI 4603b or HD 245134b** has been discovered.
- An **exoplanet is any planet beyond our solar system**.
  - Most **orbit** other **stars**.
  - Free-floating exoplanets, called **rogue planets**, orbit galactic center and are untethered to any star.
  - **Compositions range from very rocky** (like Earth) **to very gas-rich** (like Jupiter and Saturn).
- In a study, novel types of habitable exoplanets are identified, they are referred as **Hycean worlds**.
  - These planets would fall somewhere between Super-Earths (a type of exoplanet) with a mass higher than Earth's and mini-Neptunes in terms of mass.

3.13.3. FAST RADIO BURST (FRB)

- It is a **bright and brief burst of electromagnetic radiation.**
- Seen in **radio-wave frequencies** that usually **last thousandths of a second**.
- **FRBs lose energy when they reach Earth,** they are difficult to spot.
- As FRBs travel **through galaxies** and in between them, **they pass through hot gas**, which causes their low-**frequency radio waves to slow down** more than those at **higher frequencies**, a phenomenon known as **dispersion**.
  - This allows scientists to **detect and measure 'matter'** between galaxies that are **currently invisible to us**.
- Causes of FRBs are not entirely known.
  - However, Stellar remnants, such as white dwarfs (dense, hot, compact star remnants), neutron stars (formed by massive star collapse), and colliding galaxies are considered sources of FRBs.

3.13.4. GAMMA RAY BURST (GRBS)

- A new study suggests that GRBs **have the potential to temporarily destroy the ozone layer.**
- **About GRBs:**
  - These are **most powerful and violent explosions** in the known universe.
  - These brief flashes (**short-lived bursts)** of **high-energy light** result from explosive events such as the **birth of black holes** and **collisions between neutron stars**.
  - When GRB erupts, it becomes the brightest source of **electromagnetic radiation** (**brighter than a typical supernova**).
  - GRBs are also known to ionize molecules at the bottom of the ionosphere, but can **also affect the entire ionosphere**.

3.13.5. QUASI-MOON

- Astronomers have **discovered a new asteroid** (dubbed **2023 FW13**) **along Earth recently**.
  - It is **considered as a "quasi-moon"** or **"quasi-satellite**.
- **Orbits the sun in a similar time frame as Earth does**, but is only **slightly influenced by Earth's gravitational pull.**

3.13.6. ZERO SHADOW DAY

- Zero Shadow day is a phenomenon when the **sun** is exactly **overhead** and the shadow of symmetrical and vertical objects vanishes.
- This happens for locations between the **tropics** and is caused by the northern and southern motion of the sun during the course of a year.

3.13.7. BLAZAR

- Indian Astronomical Observatory (located in Hanle of Ladakh) has **observed the brightening of BL Lacertae (BL Lac), a blazar**.
- A **Blazar is a type of galaxy** that is **powered by a humongous black hole.**
- It is **among one of the brightest and most powerful objects** in the universe.
- It is known for **emitting highly energetic particles and radiation.**

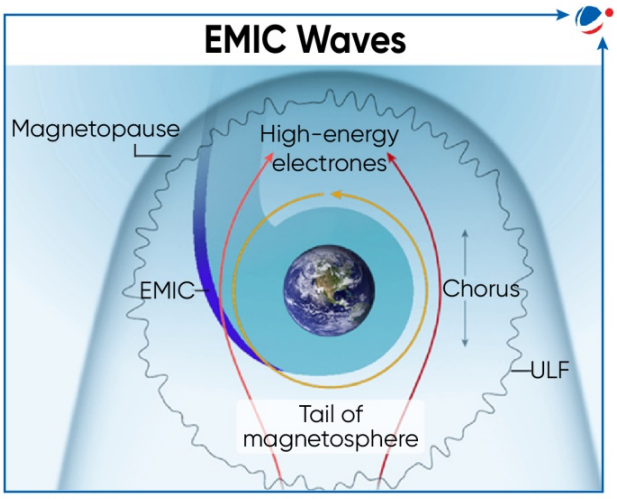
3.14. OTHER IMPORTANT NEWS

3.14.1 ELECTROMAGNETIC ION CYCLOTRON (EMIC) WAVES

- Recently, Indian Scientists identified **EMIC waves** in the **Indian Antarctic station, Maitri**.
- EMIC are the **discreet electromagnetic emissions** (transverse plasma waves) observed in the **Earth's inner magnetosphere**.

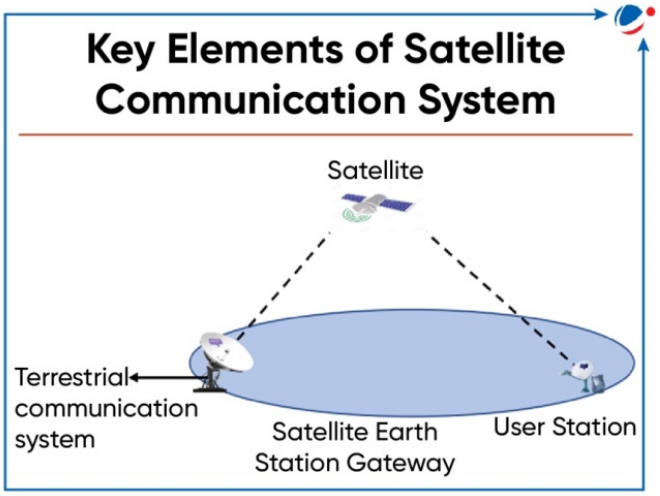
- **Plasma** is the '**fourth state of matter**'.

- It generates in the **equatorial latitudes** which propagate **along magnetic field lines** to its footprint in the **high latitude ionosphere.**
- It leads to precipitation **of killer electrons** which are hazardous to our **space-borne technology/instruments.**
- **Magnetosphere** is the region around a planet dominated by the **planet's magnetic field**.
- Also, researchers have traced a very increase in special continuous oscillations with pearl-type structures called **Geomagnetic Pc1 pearl oscillations** in the recovery phase of geomagnetic storms.
  - Pc1 pearl oscillations are amplitude-modulated structured narrow-band signals, which are signatures of low-frequency EMIC.



3.14.2. SATELLITE COMMUNICATION

- It refers to **any communication link that involves use of an artificial satellite in its propagation path**.
- **Main components:**
  - **Ground segment** (fixed or mobile transmission, reception equipment)
  - **Space segment** (satellite itself).
- **Satellite operators** need recognition for frequency and orbital resources **from International Telecommunication Union (ITU)**.
  - Government of **India assigns radio frequency spectrum** for linking to satellite.
  - **Department of Telecommunications** is licensing authority **for telecommunication services**.



- It works under the **Ministry of Information & Broadcasting** for **broadcasting services.**
- **Benefits:** Connectivity in remote locations, cost-efficient, etc.
- **Recently,** ISRO's **Space Applications Centre (Ahmedabad)** has successfully tested **Nabhmitra** for the safety of fishermen.
  - It is a **satellite-based communication system device** which enables two-way messaging services from and to the sea.

3.14.3. FLAMINGO PROJECT

- FLAMINGO is a project of the Virgo consortium for cosmological supercomputer simulations.
  - It stands for **Full-hydro Large-scale structure simulations with All-sky Mapping for the Interpretation of Next Generation Observations**.
- The **Virgo Consortium for Cosmological Supercomputer Simulations** was founded in 1994 in response to the UK's High Performance Computing Initiative.
  - It now **includes international grouping of scientists** in the UK, Germany, The Netherlands, Canada, United States and Japan.

3.14.4. FEAST (FINITE ELEMENT ANALYSIS OF STRUCTURES)

- Vikram Sarabhai Space Centre (VSSC), the lead centre of ISRO has developed FEAST, a **Finite Element Analysis (FEA) software.**
  - A **computerized method for predicting how a product reacts to real-world forces.**
  - Will be used to perform **FEA of** various types of structures including **rockets, aircraft, satellites, buildings, etc.**

3.14.5. BETELGEUSE

- Betelgeuse, **seventh brightest star in sky** (discounting the Sun), is spotted in constellation Orion. It is also called as **'Thiruvathirai' or 'Ardra' in Indian astronomy.**
- Star is in its **late carbon-burning stage** as it has **already consumed both hydrogen and helium**.
- When it would **consume all the elements of periodic table**, the gravity **would compress the core and turn it into a neutron star or a black hole**.

3.14.6. NEAR-SPACE

- China has set up **Near-Space Command for Hypersonic Weapons Force.**
- Near-Space is a region above and **adjacent** to the **national airspace** that extends from **18 km above sea level** up to 160 **km above sea level.**
  - Presently, it is a **"no man's land."**
  - In this region **air is too thin to support flight** by most **operational military aircraft** and yet **gravity is too strong** for a satellite to **sustain itself in orbit**.
  - Hence, **very few aircraft fly there**.
- **Significance of Near Space:**
  - **Systems** in this region can operate **for weeks or months** as opposed to **Unmanned Air Vehicles, whose missions last 24-40 hours.**
  - **Satellites** in this region are **less costly**

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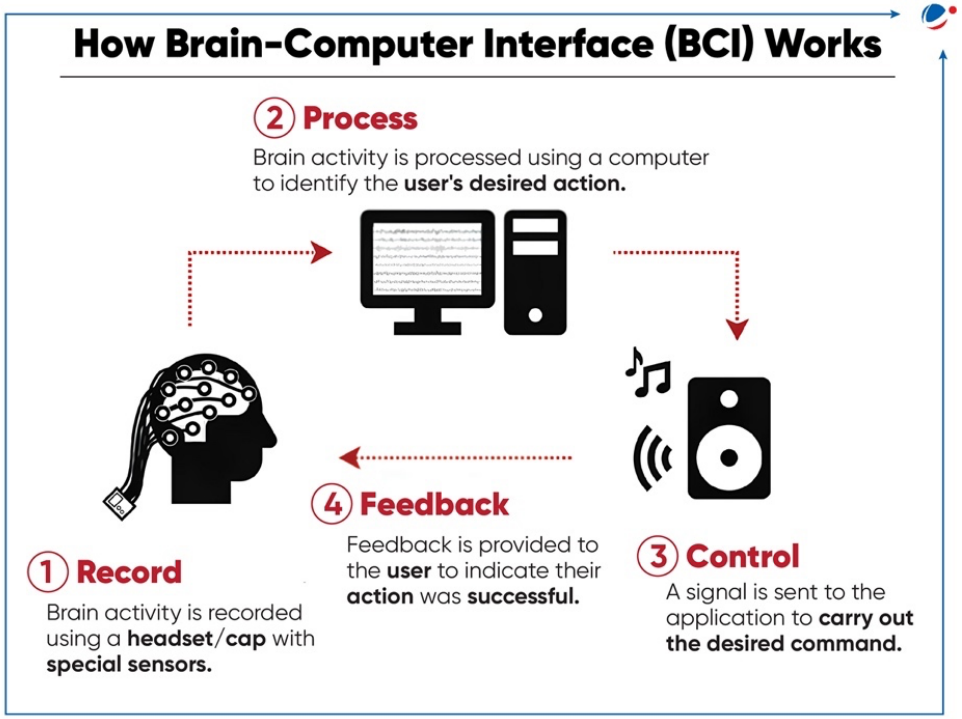
4. HEALTH

4.1. BRAIN-COMPUTER INTERFACE (BCI)

Why in the News?

Recently, Neuralink, an Elon Musk company has successfully installed a wireless **brain-computer interface (BCI)** implant in a human patient.



More about News

- In 2023, Neuralink was granted permission by the **US Food and Drug Administration (FDA) for human trials.**
- It aims to **build a next-generation brain implant with at least 100 times more brain connections** than devices currently approved by FDA.
- Initial results of trial showed promising **neuron spike detection**
  - **Spike refers to use electrical and chemical signals** to send information around the brain and to the body.
  - Neuralink also announced that their first product will be named **Telepathy**.

About Brain–Computer Interface (BCI)

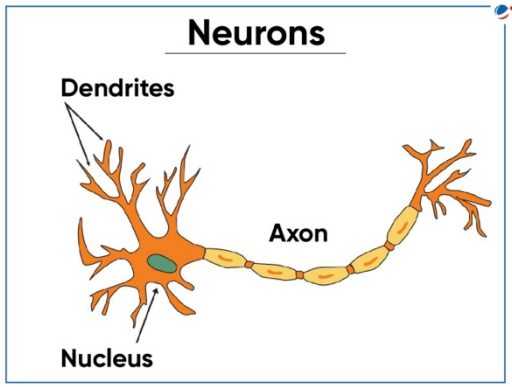
- A system that **determines functional intent** - the desire to change, move, control, or interact with something in our environment - directly from brain activity.
  - Allows controlling an application or a device using only our mind.
- **It has three main parts**:
  - A device to detect and record signals coming from the brain.
  - A computer to process and analyze the recorded brain activity.
  - An application/device to control.
- Another important part of a BCI is feedback.
- BCIs are typically divided into **unidirectional** and **bidirectional** categories based on the direction of their action.
  - Unidirectional BCIs either receive signals from the brain or send them to it, while bidirectional BCIs allow for information exchange in both directions.
- **Different techniques to measure brain activity for BCIs**
  - **Electroencephalography (EEG)**
    - ✓ **Measures electrical activity in the brain** using small, metal discs (electrodes) attached to the scalp.
    - ✓ **Brain cells communicate via electrical impulses** and are active all the time.
  - **Functional Magnetic Resonance Imaging (fMRI)**
    - ✓ Detect **the changes in blood oxygenation and flow** that occur in response to neural activity.

Key Applications of Brain–Computer Interface

- **Healthcare:** Treatment for diseases such as Parkinson's disease, epilepsy and spinal cord injuries.
- **Neuroscience and Brain Research:** Studies brain activity, connectivity, and function in real-time.
- **Improving Lifestyle:** Helping people with physical disabilities and ageing.
- **Communication Technology:** Direct interface between the brain and external devices.

About Neurons

- **Brain is made of up millions of cells called neurons.**
  - It is also known as nerve cells and **are information messengers.**
- Uses **electrical and chemical signals to send information**.
  - In it, specialized projections are called **axons**.
  - **Neuron receive signals via** rootlike extensions known as **dendrites.**
- A nerve impulse is transmitted from one neuron to another through junctions called **synapses**.
- **Three major kinds of neurons:**
  - **Sensory neurons** carry information from the sense organs to the brain.
  - **Motor neurons** control voluntary muscle activity.
  - **Interneurons,** neural intermediaries found in our brain and spinal cord.



Related Development

Brain Electrical Oscillation Signature Profiling (BEOSP)

- BEOSP, also known Brain Fingerprinting/Brain mapping/ P-300 test, is a neuro psychological method of interrogation.
  - BEOSP is designed to **bring up the information** which could be **hidden in a person's brain by sensing brain wave responses** respective to words, phrases, or pictures presented.
  - Carried out via a **process known as electroencephalogram**.
- Unlike polygraph test, **it does not involve a question answer session with accused**.
  - In a **polygraph test**, accused person's **physiological indicators are taken into account**.

Biocomputer

- Some researchers have built a hybrid **biocomputer** that can complete tasks such as voice recognition.
- **In Biocomputer**, brain cultures grown in the lab are coupled to real-world sensors and input/output devices.
  - A new area of research called "**organoid intelligence**" aims to create "**biocomputers**".

Organ on Chips (Organ Chips)

- They are systems **containing engineered or natural miniature tissues** grown inside microfluidic chips.
- These recapitulate the **complex structures and functions of living human organs.**
- Chips are designed to **control cell microenvironments** and **maintain tissue-specific functions.**
  - **Chips** are lined with **living human cells**.
  - Their tiny fluidic channels reproduce blood and/or air flow just as in the human body.
  - Itcomprise **advanced in vitro technology** that **enables experimentation with biological cells** and **tissues** outside the body.

4.2. ANTIMICROBIAL RESISTANCE (AMR)

Why in the News?

WHO in partnership with the **Global AMR R&D Hub,** has released '**Incentivizing the development of New Antibacterial Treatments 2023' Report.**

More about News

- Report is for the **G7 countries monitoring and handling of AMR.**
- **About Global AMR R&D Hub**
  - A partnership of **countries, non-governmental donor organizations and intergovernmental** organizations.
  - Launched in 2018, to a**ddress challenges and improve coordination and collaboration in global AMR R&D** using a One Health approach.
    - ✓ **One Health approach** promotes coordinated action across human and animal health, agri-food systems and the environment.

Global Steps to handle AMR

- **Global Action Plan on Antimicrobial Resistance (GAPAR) by WHO**
- **AWaRe (Access, Watch, Reserve) Tool by WHO.**
- **Global Antimicrobial Resistance and Use Surveillance System (GLASS) by WHO**
- **Global Antibiotic Research and Development Partnership (GARDP)**
- **SECURE:** First dedicated mechanism to **expand access** in Low and Low Middle Income Countries (LMICs) to **essential antibiotics** which goes beyond **access** to single products.
- **One health joint plan of action (2022–2026)** by FAO, UNEP, World Organisation for Animal Health (WOAH, founded as OIE), and the World Health Organization (WHO)

Steps Taken by India

- **National Action Plan on containment of Antimicrobial Resistance (NAP-AMR), 2017**
- **Delhi Declaration on AMR**
- **AMR Research & International Collaboration**.
- **National AMR surveillance network** of state medical college labs (NARS-Net) to generate quality data on AMR.
- **Antibiotic Stewardship program (AMSP)** to control misuse and overuse of antibiotics in hospital wards and ICUs.
- **Red Line Campaign on Antibiotics.**
- **New provision, Schedule H1 to the Drugs and Cosmetics Act** to check the indiscriminate use of antibiotics

About Antimicrobial Resistance (AMR)

- AMR occurs when **bacteria, viruses, fungi** and **parasites** evolve over time and **no longer respond to medicine.**
  - **Antimicrobials** are **medicine** used to **prevent** and **treat** infections caused by microorganisms.
  - **Antimicrobials** includes Antibiotics (for bacteria), Antiviral (for viruses), Antifungal and Antiparasitics.
- AMR makes **infections harder to treat and increasing the risk of disease**, spread severe illness and health.
- Microorganisms that develop **antimicrobial resistance** are sometimes referred to as **superbugs**.

Drivers of AMR

- Misuse and overuse of antimicrobials
- Lack of awareness and knowledge
- Poor access to quality, affordable medicine and diagnostic
- Taking incorrect doses of antibiotics to cure diseases.
- Lack of access to clean water, sanitation and hygiene
- Using antibiotics in livestock farming
- **Triple planetary crises-** Climate change, pollution and biodiversity loss

Related Concept
Biofilm

- Biofilms refer to a **thin resistant layer of microorganisms (as bacteria)** that forms on and coats various surfaces (as of catheters or water pipes).
- Biofilms **exhibits antibiotic resistance.**
- It forms on just **about any surface such as** metals, plastics, natural materials (such as rocks), **medical implants**, kitchen counters, food and food processing surfaces, contact lenses, human and animal tissue etc.

4.3. NON-COMMUNICABLE DISEASES (NCDS)

Why in the News?

Ministry of Health and Family Welfare (MoHFW) released **Strategic Operational Guidelines for National Programme for Prevention & Control of Non-Communicable Diseases (NP-NCD) 2023-2030**.

More about news

- **Other Initiatives launched during event**
  - **75/25 initiative launched:** 75 million people with hypertension and diabetes to be put on Standard Care by 2025.
  - **Shashakt Portal** for training of 40,000 Primary Health Care Medical Officers.

Key Highlights of the Guidelines

- **National Programme for Prevention and Control of Cancer, Diabetes, Cardiovascular Diseases and Stroke** (**NPCDCS**) programme has been renamed.
  - The new name is **National Programme for Prevention & Control of Non-Communicable Diseases (NP-NCD).**
  - **Programme** also included
    - ✓ Chronic Obstructive Pulmonary Disease (COPD) and Asthma
    - ✓ Non-Alcoholic Fatty Liver Disease (NAFLD)
    - ✓ Pradhan Mantri National Dialysis Programme (PMNDP) etc.

Differences between Communicable and Non- communicable diseases

	Communicable Diseases	Non-Communicable Diseases
Causes	**Highly infectious pathogens** and carriers spread these diseases	**Allergies, malnutrition**, illness brought on by internal factors, **changes in lifestyle** and surroundings, abnormal cell growth, etc.
Transmitting Agent	Viruses, bacteria etc.	Nil
Role of Inheritance	**Cannot be passed** down from one generation to another	**Can be inherited** through generations
Disease Type	**Develop immediately** and is acute	**Develops over a period of time** and lasts longer
Treatment	**Traditional methods** may work	Surgically or **specialized treatments**
Examples	Tuberculosis, Malaria etc.	Alzheimer's disease, Hypertension, Asthma etc.

About Non-communicable diseases (NCDs)

- NCDs are also known as **chronic diseases**, tend to be of long duration and are the result of a combination of genetic, physiological, environmental and behavioural factors.
- **Main Types**: Cardiovascular diseases (CVD), Cancer, Chronic respiratory diseases, and diabetes.
  - Also includes hypertension, obesity etc.
- NCDs accounted for almost **61.8% of the deaths in India in 2016.**

Initiatives taken by India to curb NCDs

- **National Action Plan and Monitoring Framework for Prevention and Control of NCDs:** Aimed at reducing the number of global premature deaths from NCDs by 25% by 2025.
- **Fit India Movement** by Ministry of Youth Affairs and Sports.

4.4. TUBERCULOSIS (TB)

Why in the news?

World Health Organisation released **Global Tuberculosis (TB) Report, 2023.**

About Tuberculosis (TB)

- TB is caused by **bacillus Mycobacterium** tuberculosis which most often affects **lungs (pulmonary TB).**
- TB can also affect other areas of the body, known as **extrapulmonary TB.**
  - Types of extrapulmonary TB include **gastrointestinal TB, skeletal TB, liver TB, etc.**
- Most common medications include **isoniazid, rifampin, ethambutol, pyrazinamide etc.**

- **Bacillle Calmette-Guerin** (BCG) is **only licensed vaccine** available for TB prevention.
  - It prevents **extrapulmonary TB** but not **pulmonary TB**.

Steps taken to prevent Tuberculosis

- **National Strategic Plan for Tuberculosis Elimination** (2017-2025)
- **TB Mukt Panchayat Abhiyan Initiative.**
- **Nikshay Poshan Yojana** provides nutritional support to TB patients.
- **Pradhan Mantri TB Mukt Bharat Abhiyan (PMTBMBA)** aims to eliminate **TB by 2025.**
  - **Under it, Ni-kshay Mitra** shall provide additional support to all on-treatment TB patients
- **"Find. Treat. All. #EndTB":** Joint Initiative of WHO, Stop TB Partnership, and Global Fund to diagnose treat and report 40 million people with TB.
- **Moscow Declaration 2017:** by WHO, to take urgent action to end tuberculosis (TB) by 2030.
- **BPaL is a six-month,** all-oral, three-drug regimen that is used to treat people with XDR TB**.** It consists of the pretomanid and two other antibiotics- Bedaquiline and Linezolid.

Drug-Resistant TB

- **Multidrug Resistance TB (MDR):** Resistant to at least **isoniazid and rifampicin**.
- **Extensively drug-resistant tuberculosis (XDR-TB):** Resistant to **isoniazid and rifampin**, **plus** any fluoroquinolone and at least one of three injectable second-line drugs (i.e., amikacin, kanamycin, or capreomycin).
- **Totally drug-resistant tuberculosis (TDR-TB):** Resistant to all first- and second-line TB drugs.

4.5. SICKLE CELL DISEASE

Why in the news?

U.S. approved First **CRISPR** based Gene Therapies to Treat Patients with **Sickle Cell Disease (SCD)**.

More about News

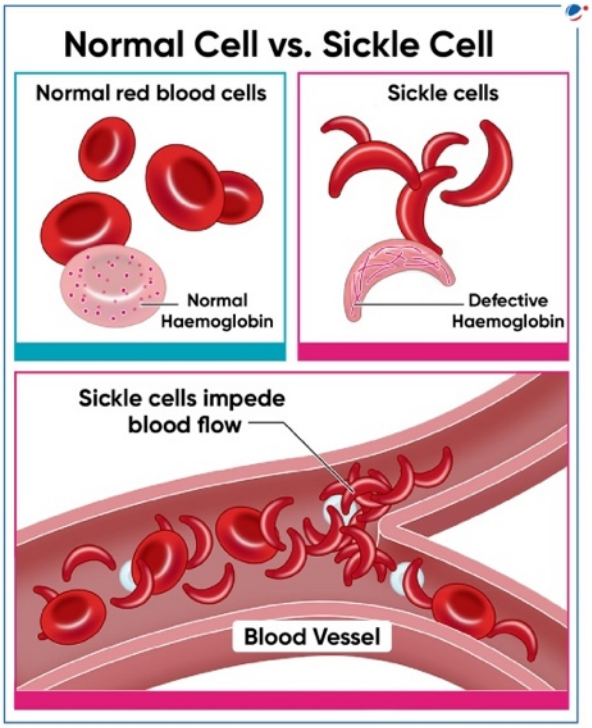
- **Casgevy** and **Lyfgenia**, first cell-based gene therapies, is approved for treatment of **SCD** in patients 12 years of age and older.
- India has also launched the **National Sickle Cell Anaemia Elimination Mission** to tackle SCD.

About Sickle Cell Disease (SCD)

- It is a type of **hemoglobin disorder**, inherited blood diseases that affect how oxygen is carried in the body.
- It is characterized by a modification in the **shape of the red blood** cell from a smooth, doughnut shape into a crescent or half-moon shape. (refer image)
  - Mis-shaped cells lack plasticity and can block small blood vessels, impairing blood flow.
- It can lead to stroke, eye problems, infections, and episodes of pain called pain crises.
- **Symptoms:** Jaundice, liver and spleen enlargement.
- In India, SCD is **more common in tribal populations**.
  - **Tribal areas were endemic to malaria for many years,** leading to many deaths, thus, as an evolutionary, their RBCs were becoming sickle-shaped. This led to their high susceptibility to SCD.
- **Stem cell or bone marrow transplants (Hematopoietic stem cell transplant)** is the **only cure for this disease**.

Inheritance of Sickle Cell Disease

- It is a genetic condition that is present at birth.
- It is **inherited when a child receives two genes—one from each parent**—that code for abnormal hemoglobin.
- **If both parents have sickle cell trait** there is a **one in four (25%) chance** that any given child could be born with **sickle cell anaemia**.
- There is also a **one in four chance** that any given child could be **completely unaffected.**
- There is a **one in two (50%) chance** that any given child will get the **sickle cell trait.**



About National Sickle Cell Anaemia Elimination Mission

- **Objective:** Provide affordable and accessible care and **eliminate** it before **2047.**
- **Strategy**: Consists of Three-pillar Health Strategy namely
  - Health Promotion;
  - Prevention;
  - **Holistic Management** & Continuum of Care.
- **Beneficiaries:** Covering the entire population from **0 to 18 years of age** and shall incrementally include the **entire population up to 40 years** as a part of the National Health Mission (NHM).

Other initiatives taken to control Sickle Cell Anaemia

- **National Health Mission (NHM)** guideline on Hemoglobinopathies (encompass all genetic diseases of haemoglobin) identifies establishing **services at the community level.**

Related Development
Haemoglobin

- A new study reported that **chondrocytes make haemoglobin** and **form haemoglobin bodies, or Hedy.**
- Previously, it was understood that it was used only by **Red Blood Cells (RBCs).**
- **About Haemoglobin**
  - **Haemoglobin** is an **iron-containing protein in the blood of animals** that **transports oxygen to the tissues.** It is present in **RBCs of vertebrates.**
  - All vertebrates **except cold-water ice fish** transport oxygen via haemoglobin.
    - ✓ In **cold-water ice fish**, oxygenation is thought to occur purely through diffusion-based transport of dissolved oxygen in the blood.
  - Haemoglobin forms an unstable reversible bond with oxygen.
  - In oxygenated state, it is called **oxyhemoglobin** (bright red) and in reduced state it is called deoxyhemoglobin (purple-blue).
  - Haemoglobin develops in cells in bone marrow that become RBCs.
  - Exhibits antioxidant properties, potentially contributing to barrier function.
  - Also identified in keratinocytes cell of the upper epidermis.

About Chondrocytes

- **Chondrocytes** cells are cells that make cartilage (connecting tissue between bones)
- **Functions of Chondrocytes**
  - It **releases substances** to **make cartilage strong yet flexible**.
  - **Haemoglobin in Chondrocytes** carries **oxygen** and is **essential for their survival.** Also, it store oxygen.

4.6. RARE DISEASES

Why in the News?

For the first time, Ministry of Health and Family Welfare introduced generic drugs for treating four rare diseases.

More about News

- It includes **Tyrosinemia-Type 1, Gaucher's Disease, Wilson's Disease and Dravet or Lennox Gastaut Syndrome- seizures.**

About Rare Disease

- A lifelong disease or disorder with prevalence of 1 or less, per 1000 population.
- **Mostly genetic in nature.**
- Currently affects 5% worldwide population.

Key initiative for rare diseases

- **National Policy for Rare Diseases (NPRD), 2021 (NPRD, 2021)** has been formulated. Its provisions include**:**
  - **Financial assistance** (under the Umbrella Scheme of Rashtriya Arogya Nidhi)
  - Categorization into 3 groups

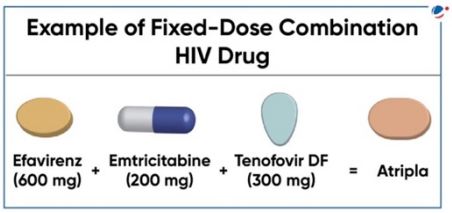
- ✓ **Group 1**: Disorders amenable to one-time curative treatment.
- ✓ **Group-2:** Diseases requiring long term/lifelong treatment having relatively lower cost of treatment.
- ✓ **Group 3:** Diseases with very high cost and lifelong therapy.

- **Exemption from Basic Customs Duty** to Rare Diseases drugs for personal use.
- **Production Linked Incentive Scheme for Pharmaceuticals** covers orphan drugs (drugs of rare diseases).

4.7. FIXED DOSE COMBINATION DRUGS

Why in the News?

Central Drugs Standard Control Organization (CDSCO) gives conditional nod for sale of Five **Fixed Dose Combinations (FDCs),** which were banned earlier.



About Fixed Dose Combination (FDC)

- Contain one or more **Active Pharmaceutical Ingredient (API)** used for a particular indication.
  - **API** is the biologically active component of a drug and it produces the **intended** effects.
- If it is combined for the first time, it would fall **under the definition of a new drug.**
- New Drugs require prior approval from the **Drugs Controller General of India (DCGI).**
  - DCGI heads the **Central Drugs Standard Control Organisation (CDSCO**).
- **Merits of FDCs: Increased efficacy, reduced cost** and **simpler logistics of distribution.**
- **Demerits of FDCs: Pharmacodynamic (Drugs power) mismatch may** leading to reduced efficacy or enhanced toxicity.
  - Decreased **shell life** and lead to **Antimicrobial Resistance (AMR).**

Steps taken by India for regulation of FDCs

- **Drugs & Cosmetics (Amendment) Act, 2008**
- **Testing capacities of Central Drugs Testing Laboratories Drugs**
- **Cosmetics Rules 1945 (**amended in 2017)

Related Development

Fixed Retail prices for Essential Medicines

- **National Pharmaceutical Pricing Authority (NPPA)** has fixed retail prices of 23 formulations.
  - It has also **revised the ceiling price of 15 scheduled formulations** under **Drugs (Prices Control) Order, 2013 (NLEM 2022).**
- **Drug Price Control in India:**
  - **The Ministry of Health and Family Welfare** draws up a **National List of Essential Medicines (NLEM) 2022** for price control.
    - ✓ These **essential medicines automatically come under the Drug (Prices Control) Order (DPCO), 2013.**
  - **NPPA**, which is an independent body in the **Ministry of Chemicals and Fertilisers, enforces these price controls.**

4.8. GENERIC DRUGS

Why in the News?

Ministry of Health and Family Welfare issued an alert to **all government doctors** in to **prescribe generic medicines only.**

About Generic Drug

- A generic drug is **a medication created to be the** same as an already **marketed brand-name drug.**
- It has **similar dosage form, safety, strength, route of administration, quality, performance characteristics**, and intended use.
- It can be marketed after the branded drug's patent expires (20 years from the date of filling the application).
  - But **compulsory licensing** under the **Indian Patent Act, 1970** allows for it without consent during any urgency.

Regulation of Generic Medicines in India

- **Indian Medical Council (Professional Conduct, Etiquette and Ethics) Regulations, 2002:**
  - **Prescribes that every physician should prescribe drugs** with generic names legibly and preferably in capital letters.
- **National Medical Commission Act, 2019**
  - Empowers the appropriate State Medical Councils or Ethics and Medical Registration Board (EMRB) of the Commission to take disciplinary action against a doctor for violation.
- **Drugs and Cosmetics Rules, 1945:** makes it mandatory to grant license for a drug formulation containing single active ingredient in proper name only.
- **Drugs Technical Advisory Board of India (DTAB**) allows pharmacies to sell generic medicines medicines to patients even if the prescriptions specify the branded versions.

Differences between Branded Drugs and Generic Drugs

Features	Branded Drugs	Generic Drugs
Patents	Patent protected	Off Patent
Price	Costly	Cheaper than branded drugs
Appearance (color, Shape, Size)	Unique look as design during product development	Need to have different appearance than branded drugs
Manufactured by	Manufactured and developed by innovator company	By Several pharmaceutical industries
Examples	Crocin	Paracetamol

Initiatives to promote Generic Medicines

- **Pradhan Mantri Bhartiya Janaushadhi Pariyojana (PMBJP**) in 2008 by **Ministry of Chemicals and Fertilizers**
- **Free Drugs Service Initiative of National Health Mission (NHM)** by **Ministry of Health & Family Welfare**
- **Production Linked Incentive (PLI) Scheme by Ministry of Chemicals and Fertilizers**

Related Development
Biosimilar

- A pharma company received grant from CDSCO for marketing authorisation of biosimilar trastuzumab (Cancer drug).
- **A biosimilar** is a medicine which is very close in structure and **function** to a biological medicine (medicine made in a living system, such as yeast).
  - **Process:** Highly specialized

4.9. INTERNATIONAL CLASSIFICATION OF DISEASES

Why in the news?

WHO's **International Classification of Diseases 11 (ICD-11)** now introduced Module 2 (ICD 11 TM 2).

More About News

- Module 2 of the supplementary chapter on traditional medicine conditions under ICD 11 is dedicated to Ayurveda, Siddha, and Unani (ASU) data and terminology.
- It encompasses more than 500 codes. Infectious diseases like Malaria and lifestyle diseases like chronic insomnia are also included.

About International Classification of Diseases (ICD-11)

- **International standard** for systematic **recording, reporting, analysis, interpretation, and comparison of mortality** and **morbidity data**.
  - Previously, **ICD-11 included Module-1** that covers **traditional medicine conditions originating in ancient China,** which is now **commonly used in Japan, Korea** etc.

- **Significance of ICD-11**
  - **Provides a list of diagnostics categories to collect and report on traditional medicine conditions** in an internationally comparable manner.
  - **Link traditional medicine practices** with **global conventional medicine's** norms.
  - Enable **integration of traditional medicine** into **insurance coverage** and **reimbursement systems**.

Traditional Medicine

- Refers to **sum of knowledge, skills and practices indigenous and different cultures** have used over time to maintain health and diagnose and treat physical and mental illness.
- **National Ayush Morbidity and Standardized Terminologies Electronic (NAMSTE) portal:** provides standardized terminologies & morbidity codes for Ayurveda, Siddha and Unani systems of medicine.
- **Ayush Health Information Management System (A-HIMS):** Comprehensive IT platform to effectively manage all functions of health care delivery systems and patient care in Ayush facilities.
- **Gujarat Declaration:** Outcome document of first WHO Traditional Medicine Global Summit 2023

4.10. FOOD FORTIFICATION

Why in the News?

Food Safety and Standards Authority of India (FSSAI) operationalized provisions of **Draft Food Safety and Standards (Food Product Standards and Food Additives) amendment regulations 2011**.

More about News

- **Notified** under **Food Safety and Standards Act 2006.**
- Imposes **limits of micronutrients** for **manufacturing of fortified rice kernels** (**FRKs**).
  - **Micronutrients includes** Iron, Vitamin B9 (folic acid), Vitamin B12 (Cynocobalamine).

About Fortification

- **Deliberately increasing the content of one or more micronutrients** in **food** or **condiments** (supplemental food)**.**
  - Regulated under **Food Safety Standards (Fortification of Foods) Regulation, 2018.**
- **About Rice Fortification**
  - It refers to adding **FRK-containing FSSAI-prescribed micronutrients (Iron, Folic Acid, Vitamin B12)** to normal Rice (Custom Milled Rice) in the ratio of 1:100.
  - **Coating**, **extrusion** and **dusting** are **key technologies**.
  - **In India, extrusion technology** is employed, where **milled rice** is **pulverized** and **mixed** with a **premix.**

Benefits

- **Combating malnutrition** and **anaemia in a cost-effective manner**.
- **Prevent** cretinism, goiter, thyrotoxicosis, brain damage **and improves foetal and neonatal health.**

Concerns

- Iron fortified rice is likely to be **harmful for patients in whom there is already iron overload** such as people suffering from **thalassemia and sickle cell anaemia.**

Key initiatives

- **Distribution of fortified rice under**
  - **Saksham Anganwadi and Poshan 2.0**
  - **Centrally sponsored pilot scheme** on "Fortification of Rice & its Distribution under Public Distribution System.
- **Fortified with (name of the fortificant)** and **+F logo** by the FSSAI**.**

Related Development
Bio-fortification

- **Biofortification** is process of **breeding nutrients into food crops.**
- It can be achieved through **agronomic practices** (involves direct fertilisation of soil), **conventional breeding** or **biotechnology-based approaches** like **genetic engineering** and **genome editing.**

- It is **slightly different from fortification** in the sense that Fortification is a **post-harvest method.**

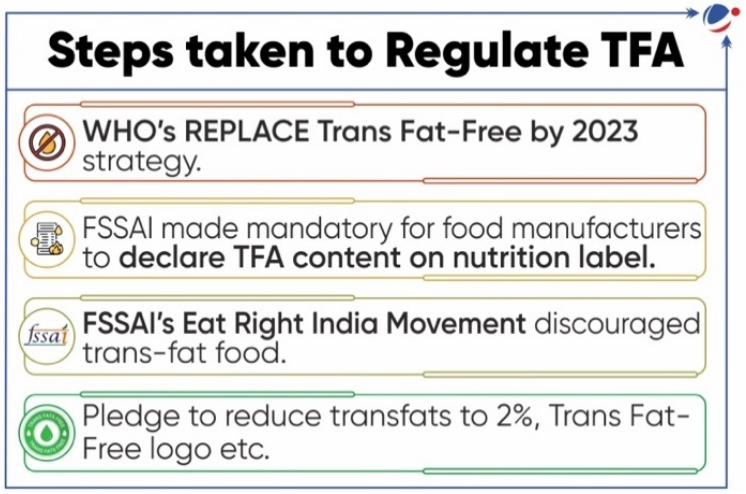
Ultra-processed Food (UPF)

- They are made mostly **from substances extracted from foods, such as fats, starches, added sugars, and hydrogenated fats.**
- High consumption of UPF combined with low physical activity **leads to issues like obesity, diabetes and cardiovascular diseases.**

4.11. TRANS-FAT

Why in the news?

World Health Organization's (WHO's) **trans-fat elimination validation programme** was opened for countries to file applications.



About Transfat

- They are **Unsaturated fats** and **are produced from vegetable oils.**
- They are commonly used in preparation of margarine and commercially baked or fried foods.
  - **There are two forms of trans- fat** i.e.,
    - ✓ **Naturally-occurring trans- fats**, occurs naturally in some dairy and meat products. They are safe.
    - ✓ **Industrially-produced transfat is formed during hydrogenation** of vegetable oil, resulting in **"partially hydrogenated" oil (PHO).**
- Trans fats are source of **non-communicable disease**.
  - Also, **associated with increased risk of heart attacks** and death from coronary heart disease.

Related Developments & Concepts

Protein binders

- FSSAI has clarified addition of **protein binders** or any other additives in dairy products are not permitted.
- Protein binders are **biological research reagents.**
  - They bind to a specific target protein to manufacture a wide range of new food products.
  - Protein binding can enhance or detract performance.
  - It **affects the digestibility of the protein-bond** and thus can **affect the biological and nutritive value of milk protein.**
    - ✓ **Milk Protein** a good source for **essential amino acids**.

Saturated Fats

- They are mainly **found in foods that come from animals** (such as meat and dairy), but they can also be found in most fried foods and some prepackaged foods.
- They are unhealthy because they **increase LDL ("bad" cholesterol) levels in body** and increase risk for heart disease.

4.12. NON-SUGAR SWEETENERS (NSS)

Why in the news?

WHO's International Agency for Research on Cancer (IARC) classified the commonly used **non-sugar sweetener (NSS) aspartame** as possibly carcinogenic to humans.

Guidelines for Usage of Artificial Sweeteners in India

- **Food Safety and Standards (Food Products Standards and Food Additives) Regulation, 2011**.
- **FSSAI has approved several artificial sweeteners such as** saccharin sodium, aspartame, acesulfame potassium, sucralose, neotame**.**

About Non-Sugar sweeteners (NSS)

- **Contains few to no calories but** has **higher sweetness intensity** per gram than sweeteners with calories—like table sugar, fruit juice concentrates etc.
- Referred as **low-calorie sweeteners (LCS)**, artificial sweeteners etc.
- Used to **enhance the flavour of foods.**
- Include **synthetically derived chemicals** and **natural extracts**.
- **Found in many beverages and foods** like frozen desserts, yoghurt, etc.
- Foods and beverages containing **LCS sometimes carry the label "sugar-free" or "diet."**

Different Types of Non-Sugar Sweeteners (NSS)	
Aspartame	• It is a methyl ester of a **dipeptide.** • Consists of two amino acids, aspartic acid, and phenylalanine. • Its perceived sweetness in humans is due to its binding of the **heterodimer G protein-coupled** (cell surface receptors that mediate physiological responses).
Acesulfame-K	• **Derived from aceto-acetic acid** and used in a wide range of non-medicinal products.
Neotame	• **A derivate of aspartame** and a general-purpose sweetener and flavor enhancer.
Sucralose	• A **zero-calorie artificial sweetener** made from sugar in a multistep chemical process.
Saccharin	• **About 300 times as sweet** as sucrose.
Sorbitol	• A **polyhydric alcohol** and used as a sweetening agent in many oral medicinal liquids.
Monk Fruit/ luo han guo/ Siraitia grosvenorii	• A **fruit extract from a plant native** to Southern China. • It is **100-250 times sweeter than sugar**.
Steviol Glycosides	• **Natural constituents of the leaves** of **Stevia rebaudiana (Bertoni) Bertoni**, a plant native to parts of South America and commonly known as Stevia. • **200 to 400 times sweeter** than table sugar.
Thaumatin	• **Group of intensely sweet basic proteins** isolated from the fruit of Thaumatococcus danielli (West African Katemfe fruit). • **Used as a sweetener in various foods,** including wine and other fermented or distilled beverages, jams, ice cream, bakery items, potato-based and similar snacks, and breakfast cereals.

4.13. CODEX ALIMENTARIUS COMMISSION (CAC)

Why in the News?

Codex Alimentarius Commission (CAC) approved India's proposal for global standards on millets, covering Finger millet, Barnyard millet, Kodo millet, Proso millet, and Little millet as group standards.

More about News

- **FSSAI has set group standards** which specify **8 quality parameters** like limits for moisture content, uric acid content, etc**. for 15 types of millets**.
  - Codex currently has **standards for Sorghum and Pearl Millet.**
- **Also, 7th Session of the Codex Committee on Spices and Culinary Herbs (CCSCH)** was recently held in India**.**
  - **In this session,** quality standards for 5 spices, namely small cardamom, turmeric, juniper berry, allpice and star anise were finalised.

- **CCSCH** has forwarded these 5 standards to **Codex Alimentarius Commission (CAC)** recommending for adoption as full-fledged Codex standards.

About CAC (1963)

- An i**nternational food standards body** and jointly established by WHO and FAO.
- Headquartered in **Rome** and has **189 members (including India).**
- Objective is to **protect consumer's health** and ensure **fair practice**s in **food trade.**
- **Codex Alimentarius, or "Food Code"** is a collection of standards, guidelines and codes of practice adopted by the CAC.
- Codex **standards are voluntary.**
- **Agreement on Application of Sanitary and Phytosanitary Measures** (SPS) of WTO **recognizes Codex standards**.

4.14. ORGAN AND TISSUE TRANSPLANTATION

Why in the News?

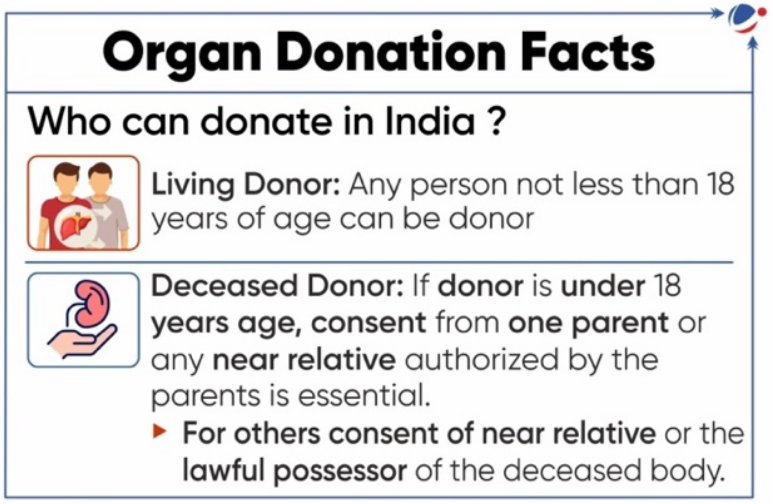
National Organ and Tissue Transplantation Organisation (NOTTO) ordered an inquiry into **'cash-for-kidney racket'** case.

About NOTTO

- Facilitates coordination and networking in organ transplantation activities.
- Works under **the Ministry of Health and Family Welfares.**

About Organ and Tissue Transplantation

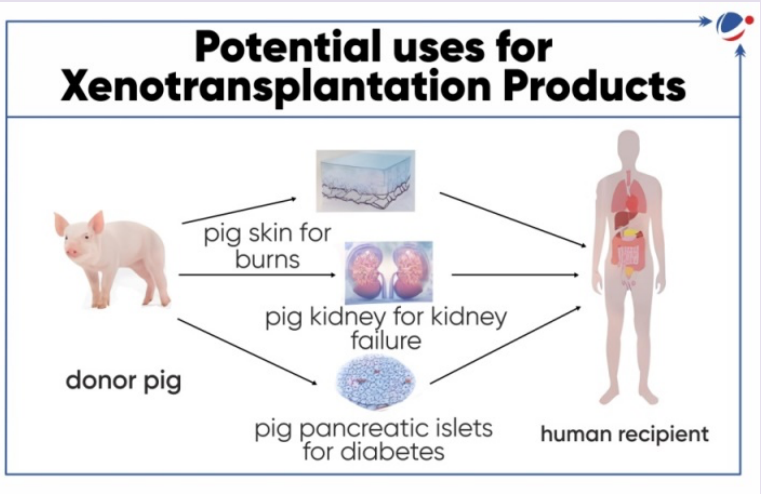
- **Transplantation** is a surgical procedure in which an organ/s, tissue or group of cells are **removed** from the donor and, transplanted into the recipient, or moved from one site to another in the same person.
  - Kidney, portion of pancreas, part of liver, a segment of lung, part of bowel can be donated by **living donors**.
- **Tissue Transplantation:** It involves corneas (eye), skin, bone, heart valves, and blood vessels etc.
  - **Transplants** of tissues **within the same person** are referred to as **autografts**, **e.g.,** Skin graft.
- **Compatibility**: Determined **immunological similarity** between the donor and recipient.
  - **E.g.,** Human Leukocyte Antigens (HLAs), blood group match etc.
- **Legal Framework:**
  - **Transplantation of Human Organs Act 1994,** allowed organ donation **by live & Brain-stem Dead** donors.
    - ✓ In 2011, amended **as Transplantation of Human Organs & Tissues Act (THOTA) 2011.**
  - **Transplantation of Human Organs and Tissues Rules**, 2014.



- **National Organ Transplant Programme**: Currently extended for the period **2021-22 to 2025-26.**
  - It establishes and maintains a **national registry of organ and tissue donation and transplantation**.
- **Modified National Organ Transplantation Guidelines:**
  - It allowed those above **65 years of age to receive an organ for transplantation from deceased donors**.
  - It also **removed the domicile requirement to register as an organ recipient**.

Xenotransplantation

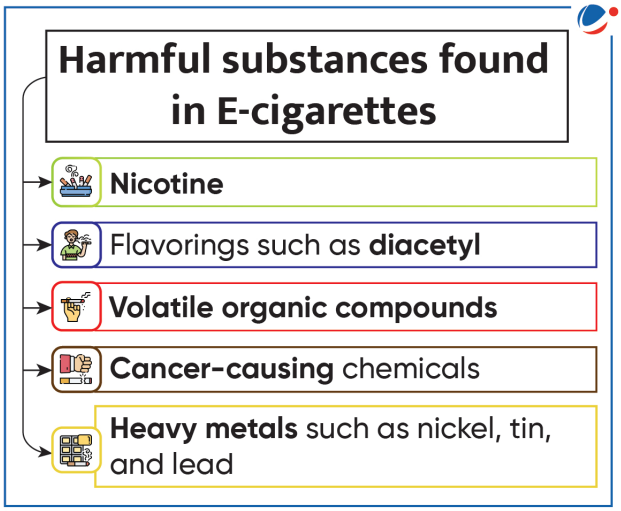
- Procedure that involves **the transplantation, implantation or infusion of non-human tissues** or organs into human recipients.
- **It includes**:
  - **Live cells**, **tissues**, or **organs** from a non-human animal source
  - **Body fluids**, cells, tissues or organs that have had *ex vivo* contact with live nonhuman animal cells, tissues or organs.
- **Generally pigs are preferred for xenotransplantation** due to large litters and grow quickly.
  - Also, they are comparatively easy to genetically modify, and are less likely to transmit infections.



4.15. E-CIGARETTES

Why in the News?

As per **World Health Organization (WHO)**, urgent action is needed to protect children and prevent the uptake of e-cigarettes.



About e-cigarettes

- The **Prohibition of Electronic Cigarettes (Production, Manufacture, Import, Export, Transport, Sale, Distribution, Storage and Advertisement) Act, (PECA)** 2019 banned e-cigarette in India.

The act defines electronic cigarette or e-cigarette (under Section 3) as-

- An electronic device that heats a substance, which may or may not contain nicotine and flavors, to create an aerosol for inhalation.
- It includes all forms of Electronic Nicotine Delivery Systems, Heat Not Burn Products, e-Hookah, etc.
- However, it does not include any product licensed under the Drugs and Cosmetics Act, 1940.
- They are sometimes called "mods," "vape pens," "vapes," "tank systems," and "electronic nicotine delivery systems (ENDS)."
- **Working:** They produce an aerosol that is inhaled by the user, by heating a liquid that usually contains nicotine, flavorings, and other chemicals.
- Act defines **e-cigarettes** as an electronic device that heats a substance, which may or may not contain nicotine and flavors, to create an aerosol for inhalation.
  - It includes **all forms of Electronic Nicotine Delivery Systems, Heat Not Burn Products, e-Hookah, etc.**
  - However, it **does not include any product licensed under the Drugs and Cosmetics Act, 1940.**
- Also called "mods," "vape pens," "vapes," "tank systems," and "electronic nicotine delivery systems (ENDS)."
- They produce an aerosol that is **inhaled by the user, by heating a liquid that usually contains nicotine, flavorings, and other chemicals**

4.16. PREPAREDNESS AND RESILIENCE FOR EMERGING THREATS (PRET) INITIATIVE

Why in the news?

World Health Organisation (WHO) launched **Preparedness and Resilience For Emerging Threats (PRET)** Initiative.

About PRET Initiative

- **An innovative approach** to improve **disease pandemic preparedness**.
  - R**ecognizes that the same systems, capacities, knowledge, and tools** can be leveraged and applied for groups of pathogens based on their mode of transmission (respiratory, vector-borne, foodborne etc.).
  - Provides a **platform for national, regional and global stakeholders** to collaborate to strengthen preparedness.
- Operates under the aegis of the **International Health Regulations (IHR)**.
  - IHR 2005 is a **legally binding agreement** of 196 States Parties.
  - IHR includes all 194 Member States of **WHO** to build the **capability to detect and report potential public health emergencies worldwide.**

Related Development

SPECS 2030 Initiative

- **A WHO initiative** which aims to address global vision impairment and blindness.
- It ensures access to eye care and treatment for all.
- **Purpose**: Reporting of the number of people who receive spectacles.

The Big Catch-Up

- Implemented by **WHO, UNICEF, Gavi, the Vaccine Alliance and Bill & Melinda Gates Foundation**, along with **Immunization Agenda 2030** and other health partners.
- Targeted global effort to **boost vaccination among children** aiming to reverse the **declines in childhood vaccinations driven by COVID-19** pandemic.

International Pathogen Surveillance Network (IPSN)

- **Launched** by **WHO**.
- A **global network to help swiftly detect threat from infectious diseases**, like COVID-19, and share the information **to prevent their spread**.
- Provides a **platform for connecting countries and regions,** improving systems for collecting and analysing samples.

Public Health Emergency of International Concern (PHEIC)

- **WHO declared end** to **COVID-19** as Public Health Emergency of International Concern (PHEIC).
- On the recommendation of the **International Health Regulations (IHR) 2005 Emergency Committee.**
- An **extraordinary event** which is determined to **constitute a public health risk to other States** through **international spread of disease** and to **potentially require a coordinated international response".**
- WHO also released the **2023-2025 COVID-19 Strategic Preparedness and Response Plan (SPRP).**

4.17. DISEASES IN NEWS

4.17.1. VIRAL DISEASES

4.17.1.1. CHIKUNGUNYA

- US. has approved **world's first vaccine** for chikungunya named **Ixchiq**.
- A **mosquito-borne disease** caused **by chikungunya virus** (CHIKV)**.**
- **Transmission**: Mosquito **Aedes (Stegomyia) aegypti** and **Aedes (Stegomyia) albopictus**.
  - These mosquitos **bite primarily during daylight** hours.

- Can be **passed from a pregnant mother to an unborn child** and can be fatal to newborns.
- Included in India's **National Vector Borne Diseases Control Programme**.

4.17.1.2. ZIKA VIRUS

- First case of **Zika virus** has been reported in Mumbai, Maharashtra.
- **Transmitted primarily by Aedes mosquitoes**, which bite **mostly during the day**.
  - **Same mosquito transmits yellow fever**.
  - It **is associated with Guillain-Barré syndrome**, **neuropathy and myelitis** in adults and children.
  - **Transmitted from mother to fetus during pregnancy**, through sexual contact, transfusion of blood and blood products, and organ transplantation.

4.17.1.3. SWINE FLU STRAIN H1N2

- UK has Confirmed the **First Human Case** of **Swine Flu Strain H1N2**
- **About Swine Flu Strain H1N2**
  - Caused by **swine influenza viruses**
  - **Transmission: Direct or indirect exposure to pigs** or contaminated environments carrying the pathogen.
  - **Symptoms:** Similar to **regular flu** and include fever, cough, etc.

4.17.1.4. LUMPY SKIN DISEASE (LSD)

- More than 100 Cows have died of LSD in Meghalaya.
- An **infectious viral disease** mainly affecting **cattles**, causing **fever, nodules on skin** and occasionally **death**.
  - It also causes **reduced milk yield of animals**.
- Originally found in **Africa**, it has also spread to countries in **Middle East, Asia**, and **Eastern Europe**.
  - **Transmitted by blood-feeding insects**, such as certain species of flies and mosquitoes, or ticks.
  - Its spread can be controlled through **attenuated virus vaccines.**

4.17.1.5. HEPATITIS C

- According to WHO, **Egypt** became the **first country to achieve "gold tier" status** on path to **elimination of hepatitis C**.
- It is a **viral infection** that affects **the liver.**
  - **Transmission:** Reuse or inadequate sterilization of medical equipment, especially syringes and needles in healthcare settings.
  - Hepatitis B virus is **transmitted much like HIV.**
  - Globally, the number of people infected with **Hepatitis B and C viruses are several times more than those infected with HIV.**
  - Some of those infected with Hepatitis B and C viruses **do not show the symptoms for many years.**
  - There is **no vaccine for hepatitis C,** but it can be **treated with antiviral medications.**
    - ✓ Whereas, effective vaccine available for **Hepatitis A and B.**

4.17.1.6. NIPAH VIRUS (NIV)

- Kerala has witnessed outbreak of NiV.
- NiV is a **zoonotic virus** (transmitted **from animals to humans**).
  - Can also be transmitted through **contaminated food or directly between people**.
  - **Fruit bats** of **family (Pteropodidae) and genus (Pteropus)** are the natural hosts for **Nipah virus.**
- In **zoonotic disease**, pathogens may be bacterial, viral or parasitic, or other unconventional agents.
  - The other prominent zoonotic disease includes Rabies, Brucellosis, Japanese encephalitis, Plague, etc.
  - Their spread has increased due to use of antibiotics in animals, reduction in forest cover, etc.

4.17.1.7. AVIAN INFLUENZA A (H9N2) VIRUS

- Union Health Ministry is closely **monitoring the reported outbreak of H9N2 in China.**
- A **subtype of the influenza A virus**.
- Causes human influenza (rare) as well as bird flu.
- **H1N1 flu, sometimes called swine flu,** is a type of influenza A virus.
- Found **worldwide in wild birds and are endemic in poultry in many areas.**
- Transmission takes place due to **exposure to infected poultry or contaminated environments.**
- **Indian Council of Agricultural Research-National Institute of High-Security Animal Diseases (ICAR-NIHSAD)** developed an 'Inactivated low pathogenic avian influenza (H9N2) vaccine for chickens'.

4.17.2. OTHER DISEASES IN NEWS

4.17.2.1. NOTIFIABLE DISEASE

- A **notifiable disease is required by law** to be reported to government authorities.
  - **WHO's International Health Regulations, 1969 require disease reporting to WHO** to help with its global surveillance and advisory role.
  - Accordingly, **Centre has notified several diseases** such as cholera, leprosy, meningitis, pertussis (whooping cough), plague, TB, AIDS, hepatitis, etc.
  - Onus of **notifying any disease** and implementation **lies with state government.**

4.17.2.2. LYMPHATIC FILARIASIS (LF)

- Ministry of Health and Family Welfare inaugurated **the 2nd phase of the Mass Drug Administration (MDA) initiative to eliminate LF by 2027.**
- LF is a **neglected tropical disease (NTD)** commonly known as elephantiasis.
  - Caused by microscopic, parasites **nematodes** (roundworms) of the family **Filariodidea**.
  - Spread through **mosquitoes**.
  - Impairs the **lymphatic system** and can lead to the **abnormal enlargement of body parts** (lymphedema and elephantiasis).

4.17.2.3. NEGLECTED TROPICAL DISEASE (NTD)

- WHO has notified **Noma as NTD.**
  - **Noma (cancrum oris)** is a severe gangrenous disease of mouth and face.
  - It mainly **affects children aged 2–6 years old suffering from malnutrition**, living in extreme poverty with poor oral health.
  - **Africa** is most affected continent.
- **NTD is caused by a variety of pathogens** including viruses, bacteria, parasites, fungi and toxins.
- **NTDs include**: Dengue and chikungunya, Rabies, leishmaniasis; leprosy; lymphatic filariasis etc.
- **India has successfully eliminated certain NTDs** like guinea worm, trachoma, and yaws.
- **Initiatives to tackle NTDs**
  - **London Declaration on NTDS**
  - **Kigali declaration on NTDs** adopts the targets to eradicate or control NTDs by 2030.

4.18. KEY CONCEPTS/TERMS IN NEWS

4.18.1. PHAGE THERAPY

- Recently, study found that the **public accepts use of bacteria-killing viruses (Phage Therapy)** as an alternative to antibiotics.
- **Phage Therapy** involves **using Bacteriophages to treat bacterial infections**.
  - **Bacteriophages** are **viruses** that **infect and replicate only** in **bacterial cells**.

- **Significance: Unlikely to damage human cells** due to significant differences in bacterial cells and human cells.
  - Inherently **non-toxic** in nature.

4.18.2. MACROPHAGES

- As per Cancer Cell Study, **senescent macrophages in the lung promoted tumor growth.**
  - **Senescent cells do not die** and are **not usually eliminated from body. They can stay** and **build in tissues**. They are also referred to as **"zombie cells".**
- Macrophages are a **type of white blood cell** that acts as the body's first line of defence against infection.
  - They are large, specialized cells that **recognize, engulf and destroy target cells.**

4.18.3. NUCLEAR MEDICINE

- Russia undertook an initiative for **BRICS collaboration in Nuclear Medicine.**
- Nuclear Medicine is a **medical specialty that uses radioactive tracers** (radiopharmaceuticals) to assess bodily functions and **to diagnose and treat disease.**
  - **Risks:** Added exposure to ionizing radiations can **increase risk of developing cancer.**
  - Radioactive tracers are **used in imaging tests that help find problems inside the body**.
    - ✓ These **tracers give off particles that can be detected** and turned into a picture to help find problems in organs or other structures.
    - ✓ **Cobalt-60 is used medically for radiation therapy** as implants and as an external source of radiation exposure.

4.18.4. HELA CELLS

- HeLa cells were the **first human cells to be successfully cloned.**
- These cells **never reached the point of senescence**, since due to mutations, it has achieved the ability to keep on dividing.
  - Normally, human cell cultures die within a few days after a set number of cell.
- **Significance:** Test the effects of radiation, cosmetics, gene mapping and studying human diseases, etc.
- In **Cell culture**, cells are grown in a Petri dish, in a lab in controlled conditions.

4.18.5. CERVAVAC VACCINE

- A study in Lancet Oncology reveals that the **Cervavac vaccine** by the Serum Institute of India elicits a comparable immune response to **Merck's Gardasil vaccine**.
  - Cervavac is India's **first indigenous quadrivalent Human papillomavirus (HPV) vaccine** for the prevention of cervical cancer and other HPV-associated cancers.
    - ✓ Cervavac addresses only **HPV types 6, 11, 16 and 18.**
    - ✓ It can be given to **both genders and age group 9 to 26 years.**
  - HPV (sexually transmitted infection) is **a major cause** of cervical cancer.

4.18.6. INVERSE VACCINE (IV)

- Researchers developed an **Inverse Vaccine against autoimmune diseases** at the University of Chicago.
  - **In autoimmune diseases,** the **immune system** attacks **healthy tissue e.g., psoriatic disease,** etc.
- **Mechanism of IV**
  - It **makes the immune system forget a specific molecule** by using a special property of the liver- naturally marks certain molecules as not harmful to the body.
  - Vaccine combines two things: **an antigen** (a molecule that the immune system attacks) and **a molecule that looks like a part of an old cell**.
  - Liver recognition of old cell parts as "friends" tricks the immune system, and does not attack antigens.
- **Unlike traditional vaccines that give the immune system a glimpse of a pathogen to prime it to fight**

- Inverse vaccines **reintroduce the friendly self-antigen t**hrough a process that encourages the immune system to ignore it while functioning normally.

4.18.7. MONOCLONAL ANTIBODIES (MABS)

- The **Centre** decided to **procure** doses of monoclonal antibody from **Australia.**
- Monoclonal antibodies (mAbs) are **artificial antibodies** which mimic the **activity of our immune systems.**
  - **They are produced through a process that involves extracting specific antibodies** from human blood and **then they cloned.**
    - ✓ They are **clones of just one antibody**, and they bind to one antigen only**.**
  - They are made by **homogeneous hybrid cells (B cells)** derived from the same parent cell.
    - ✓ **Polyclonal antibodies (PAbs),** on the other hand, are a mixture of antibodies that are secreted by different B cell lineages.
  - They have been used in the treatment of cancers**, Ebola, HIV etc.**
  - **Hybridoma technology** is used most common method to produce mAbs.

4.18.8. OPTICAL TWEEZERS

- **Using optical tweezers,** researchers at Raman Research Institute (RRI), attempted to **study structural details of Laponite**, a synthetic clay.
  - RRI is an **autonomous institute funded by Department of Science and Technology**.
- **Optical tweezers are scientific instruments that use a highly focused laser beam** to hold and move microscopic and sub-microscopic objects like atoms, nanoparticles and droplets, in a manner similar to tweezers.
  - If the object is held in air or vacuum without additional support, it can be called **optical levitation.**
- In 2018 **Arthur Ashkin won the Nobel Prize in Physics "for the optical tweezers** and their application to biological systems.

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COMPONENTS OF AN IMPACTFUL ANSWER

Identification of Context: Understanding the specific theme or topic of the question, and situating the response within its relevant context.

Content Competence: Demonstrating a comprehensive grasp of the subject matter, supported by accurate facts, relevant examples, and insightful analysis.

An impactful Introduction: Engagingly setting the stage for the answer, capturing the examiner's attention while providing a brief overview of the discussion to follow.

Structure and Presentation: Organizing the answer coherently with clear headings, subheadings, or bullet points, and presenting information logically and aesthetically for easy comprehension.

Balanced Conclusion: Summarizing key points concisely, offering insights or recommendations if applicable, and providing a satisfying closure to the argument or discussion.

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5. ALTERNATIVE ENERGY

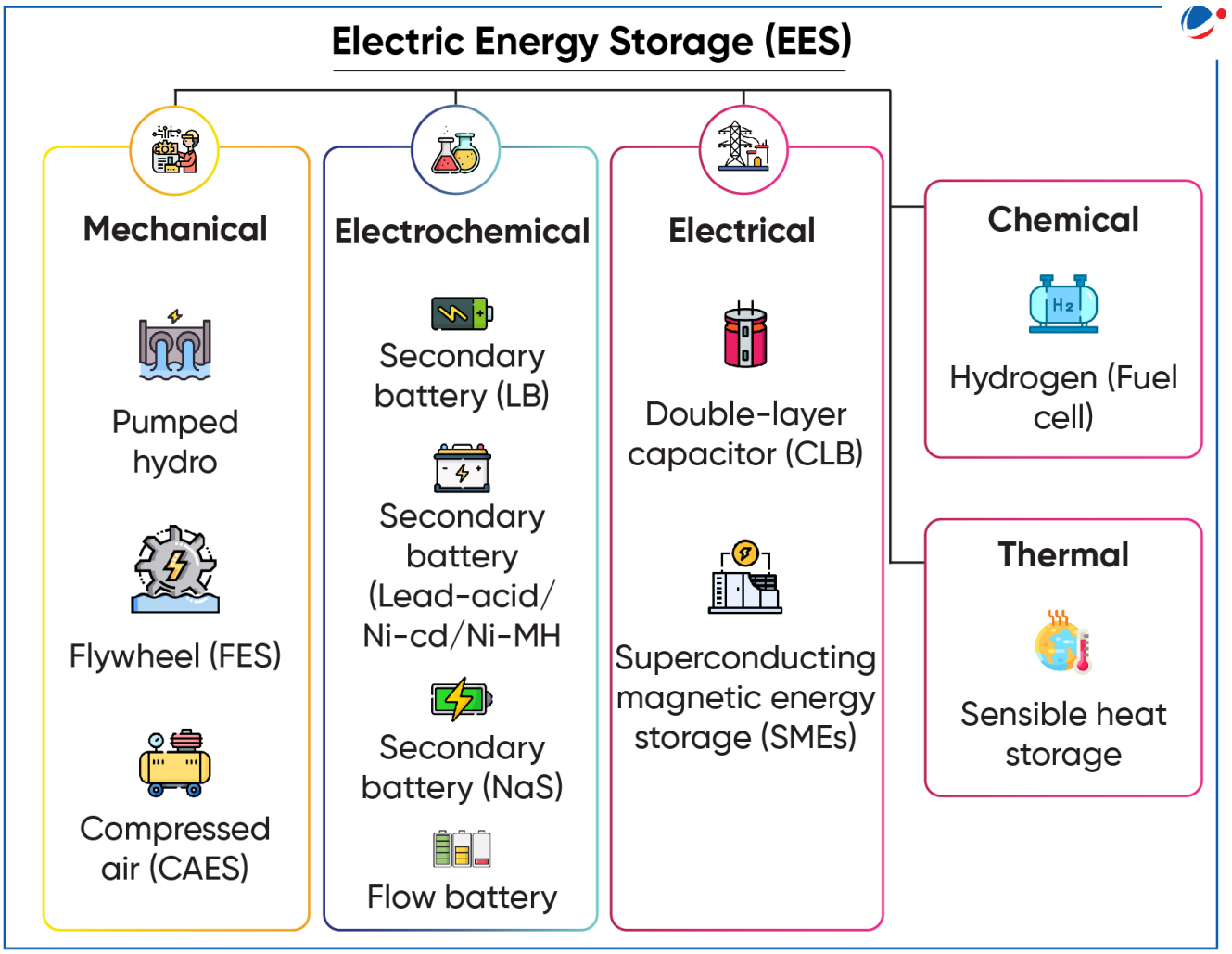
5.1. BATTERY ENERGY STORAGE SYSTEM (BESS)

Why in the News?

Solar Energy Corporation of India Limited (SECI) has successfully commissioned **India's largest Battery Energy Storage System (BESS)** in Chhattisgarh.

More about News

- Commissioned BESS stores energy using solar energy.
- **SECI** works under the aegis of the **Ministry of New and Renewable Energy.**
- Earlier, Union Cabinet has approved a scheme for **Viability Gap Funding (VGF)** for development of BESS.



About Battery Energy Storage System (BESS)

- Categorized under the electrochemical storage system which uses **different electrochemical reactions to store electricity.**
  - **ESS** can be used independent of or as a part of, power system infrastructure at various levels in generation, transmission, and distribution.
- **Types of BESS**
  - **Standard (non-flow) batteries:** Consists of pairs of plates **(electrodes)** immersed in **electrolyte**.
    - ✓ Electrodes are separated by non-conducting materials. It includes

- Lead-Acid (PbA) battery
- Nickel-Cadmium (Ni-Cd) battery
- Lithium-Ion (Li-Ion) battery
- Sodium-Sulfur (Na-S) battery

- **Flow batteries:** Uses **tanks of electrolyte** and **membrane to control the flow of electrons** and pumps to control the flow of electrolyte.
  - ✓ Redox Flow Battery (RFB)
  - ✓ Hybrid Flow Battery (HFB)

Key highlights of the scheme

- Envisages development of 4,000 MWh of BESS projects by 2030-31.
- Financial support of up to **40% of the capital cost in the form of VGF**.
  - VGF is a grant, one-time or deferred.
    - ✓ VGF is provided **to support infrastructure projects** that are **economically justified** but fall short of **financial viability**.
- Scheme targets to achieve **a Levelized Cost of Storage (LCoS) ranging from ₹5.5-6.6 per kWh**.
  - **LCoS** will make stored renewable energy a viable option **to manage peak power demand**.
  - LCoS is the **total cost of the BESS divided by the energy** it is projected to provide over the course of its useful life.
- A minimum of **85% of the BESS project capacity** will be made **available to Discoms**.
- **Ministry:** Ministry of Power

5.1.1. LI-ION BATTERY

Why in the News?

Recently, Nobel laureate and co-inventor of Lithium-ion (Li-ion) batteries, John Bannister Goodenough passed away.

About Li-ion battery

- A **rechargeable** battery, in which lithium ions move from the negative electrode to positive electrode during discharge and back when charging.
  - **Materials used as electrodes include:** Lithium cobalt oxide (cathode), lithium manganese oxide (used in electric automobiles), and lithium iron phosphate.
    - ✓ **Goodenough developed** a lithium battery with **a cathode of cobalt oxide**.
  - Li-ion batteries **use ether** (a class of organic compounds) **as an electrolyte**.
  - **Solid-state lithium batteries** has excellent **potential energy density.**
    - ✓ A **solid-state battery** uses solid electrolyte, not liquid.
- **Advantages of Li-ion battery:**
  - Light weight and has high energy density, have 5000 cycles or more compared to just 400- 500 cycles in lead acid batteries.
  - Requires low maintenance, low self-discharge rate, no **memory effect** etc.
    - ✓ In **Memory effect**, **repeated partial discharge/charge cycles** can cause a battery to '**remember' a lower capacity.**
- **Disadvantages of Li-ion battery:** High-price, tendency to overheat, can lead to thermal runaway and combustion, etc.

Other Batteries/Systems in News

Advanced Chemistry Cells (ACC) Battery

- **Ministry of Heavy Industries announced re-bidding of ACC manufacturing** under PLI Scheme on 'National Programme on Advanced Chemistry Cell (ACC) Battery Storage.
- A **new generation** of advanced **storage technologies.**
- **ACC** can **store energy, either as electrochemical or as chemical energy**.

Biodegradable Paper Supercapacitor

- Scientists at **Gujarat Energy Research and Management Institute (GERMI) have developed** paper-based supercapacitor.
- It is **thinnest, lightweight and biodegradable** in nature.
  - It is an **electrochemical charge storage device.**
  - It has a fast charging/discharging cycle, high power density and a longer life cycle.
- Developed from **seaweed** (marine macroalgae).

Gravity battery

- A gravity battery involves **lifting** (charging) and **lowering** (discharging) a heavy weight.
- **Functioning**:
  - When there is plenty of green energy, the batteries **use the power to lift a heavy weight (or blocks)** either high into the air or to the top of a deep shaft.
  - When electricity demand picks up, the blocks are lowered one by one, releasing **kinetic energy that is used to rotate a motor and generate electricity**.

Sodium Ion Battery (SIB)

- **SIB** utilizes **sodium ions as charge carriers** to **store** and **release electrical energy.**
- SIBs are currently evolving as a viable **substitute for lithium-ion batteries (LIBs)** due to their **low cost and natural abundance of sodium resources.**
- **Significance of SIBs:** Wider temperature tolerance, can even be stored and transported at zero voltage state, etc.

5.2. SMALL MODULAR REACTORS (SMRS)

Why in the news?

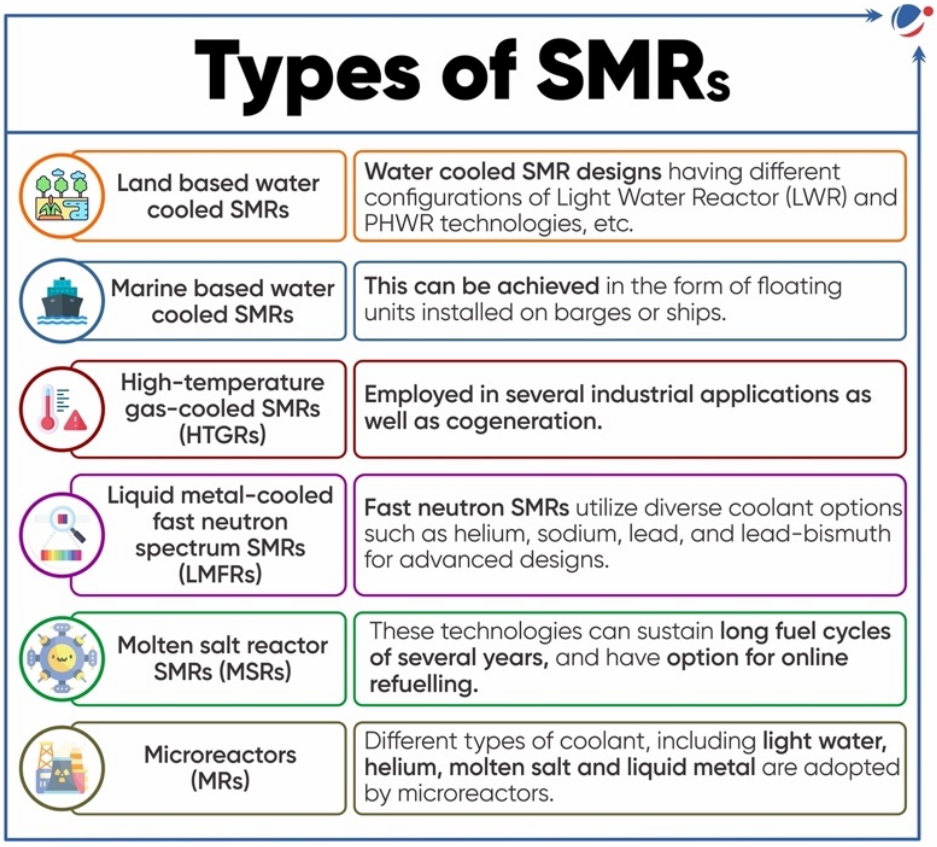
China launched the world's **first fourth-generation nuclear reactor**. It used **Small Modular Reactor (SMR) design** in it.

More on News

- Fourth-generation nuclear reactor uses **gas (helium)** for cooling unlike conventional power plants that **use pressurised water.**

About SMRs

- **SMRs** are **advanced nuclear reactors, power generation capacity ranging** from less than **30 MWe** to **300+ MWe.**
- **SMRs:**
  - **Small**- Physically a fraction of the size of a conventional nuclear power reactor.
  - **Modular**- Systems and components to be **factory-assembled** and transported as a unit to a location for installation.
  - **Reactors**- Harness nuclear fission



Advantages of SMRs

- **Adaptable and scalable**
- **Longer refueling interval** (only need to refuel every three to seven years, as opposed to every one to two years for traditional plants)
- **Compact design**
- **Passive safety features** (**to shut down and cool the reactor** under abnormal circumstances)
- **Economical** (adaptability to allow co-generation, supply heat for desalination and manufacturing etc.)

International Nuclear Liability Conventions

- **Vienna Convention** on **Civil Liability** for **Nuclear Damage, 1963**
- **Convention on Supplementary Compensation** for Nuclear Damage, 1997
- **Paris Convention** on Third Party Liability in the Field of Nuclear Energy, 1960
- **Joint Protocol** Relating to the Application of the Vienna Convention and the Paris Convention, 1988
- **Brussels Supplementary Convention** to the Paris Convention, 1963.

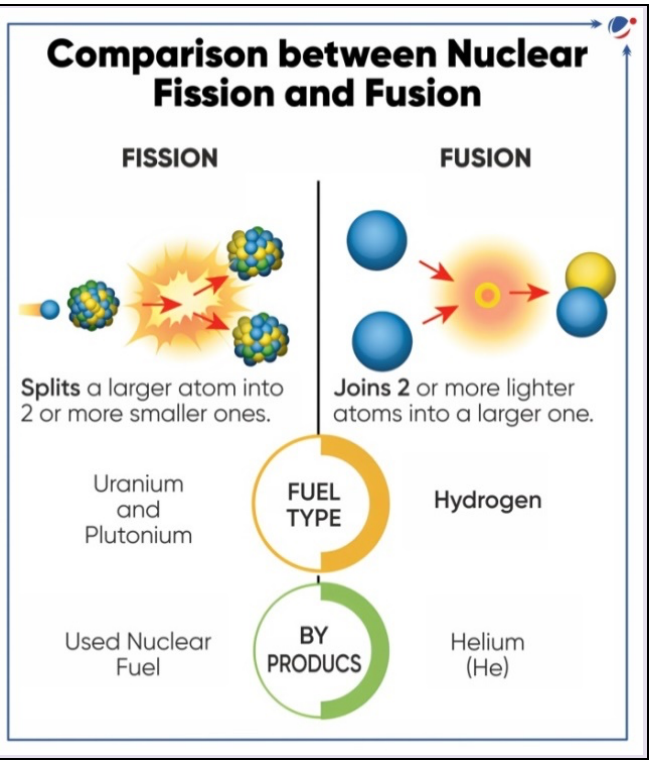
5.3. NET ENERGY GAIN (NEG)

Why in the News?

US scientists achieved **Net Energy Gain (NEG)** for second time **in nuclear fusion reaction.**

About Nuclear Fusion

- A process in which **two light atomic nuclei combine** to form a **single heavier one** while **releasing massive amounts of energy**.
  - Occurs in a **state of matter called plasma-hot, charged gas made of positive ions and free-moving electrons**
  - In fusion, **two positive nuclei have to come close** to each other.
    - ✓ However, they repel each other—this phenomenon is called the **Coulomb Barrier**.
    - ✓ To overcome this barrier, massive **energy is required.**
    - ✓ This energy is presently more than the energy generated from the fusion reaction.
- **Significance of Nuclear Fusion:**
  - **Clean and safe power**
  - 1 kg fusion fuel provides **as much energy as 10 million kilograms of fossil fuel**.
  - **Hydrogen** is available in abundance.



About Net Energy Gain (NEG)

- **NEG,** critical for commercial fusion power, implies **nuclear fusion process** generate **more energy than** the nuclear fusion process **consumes**.
- **India is a part of the International Thermonuclear Experimental Reactor (ITER) project** to demonstrate NEG from the fusion reactors.
  - India has also constructed its indigenous **tokamak ADITYA and semi-indigenous Steady State Superconducting Tokamak (SST-1)**.
- **About ITER**
  - Aims to **demonstrate nuclear fusion as a clean green source of energy**.

- Located in **France** and is a collaboration of China, EU, **India,** Japan, Korea, Russia and US.
- Aims to **build world largest tokamak,** a magnetic fusion device designed to tap into the potential of fusion energy.
  - ✓ **Tokamak** operates on same principles that power the Sun and stars.

Related Development

Julius Robert Oppenheimer (1904- 1967)

- He was a **renowned American physicist.**
- Played a **key role in the success of Manhattan Project (MP).**
- **MP** is code name for **American-led effort to develop a functional atomic weapon** during World War II.
- His research helped in **creation of first nuclear bombs**.
- He is often known as the **"father of the atomic bomb.**
- He also worked on **fast neutron physics**.
- Later, he actively **opposed nuclear weapons** and their **unchecked proliferation**.

JT-60SA: Experimental Nuclear Fusion Reactor

- World's biggest experimental nuclear fusion reactor **JT-60SA** was recently inaugurated in **Japan**
- A joint initiative between **European Union and Japan**.
- It is a forerunner for under-construction **ITER.**

5.4. KAKRAPAR NUCLEAR POWER PLANT (KAPP 3)

Why in the new?

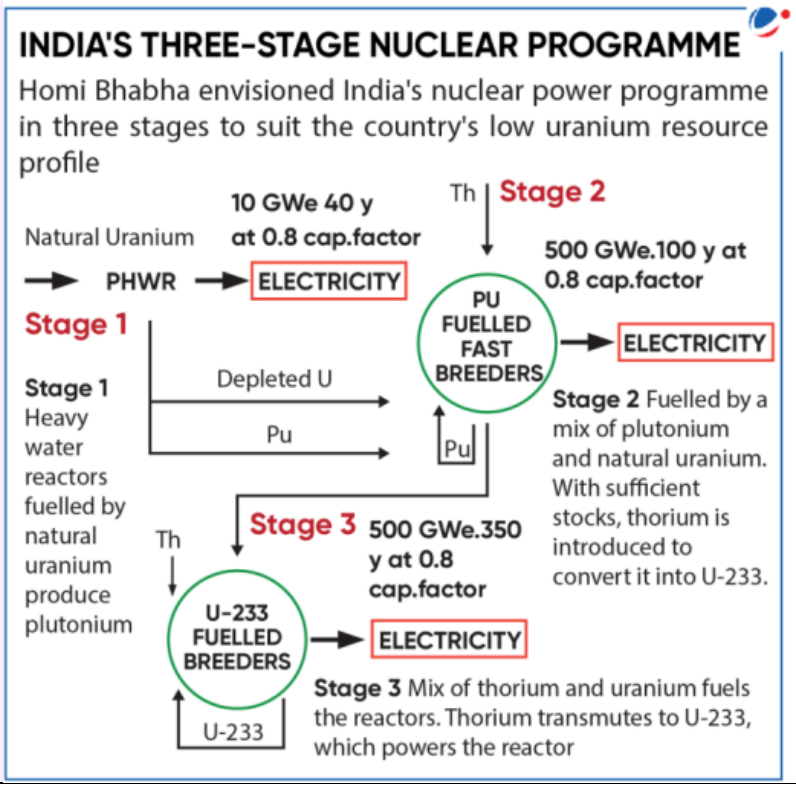
First **largest indigenous 700 MWe** Kakrapar Nuclear Power Plant (KAPP 3) recently **started working in Gujarat.**

About KAPP 3

- KAPP3 is the **largest indigenous nuclear power reactor**, built by Nuclear Power Corporation of India Limited (NPCIL) (undertaking of Department of Atomic Energy).
- Biggest indigenously developed variant of the **Pressurised Heavy Water Reactor (PHWR).**
  - In 2020, it had achieved its **first criticality.**
    - ✓ Criticality refers to a condition in **nuclear reactor operations where the number of neutrons produced by fission reactions is sufficient** to sustain a self-sustaining chain reaction.
  - PHWRs use **natural uranium as fuel and heavy water as moderator**.

Nuclear power in India

- India is currently in the **second stage of its three-stage** nuclear programme



- In related development, Kakrapar-4 has also recently attained criticality.
  - Kakrapar-4 is the **second in the series of sixteen indigenous PHWR** of 700 MW each being set up in the country.

Related Development

Uranium enrichment

- According to the IAEA report **Iran has expanded stock** of near-weapons grade uranium.
- **Weapon-grade uranium** is commonly considered to have been **enriched above 90% U-235.**
- Uranium enrichment is a process **to create an effective nuclear fuel** out of mined uranium by **increasing the percentage of uranium-235 (**U-235**).**
  - Uranium found in nature contains only **0.7% of the chain-reacting isotope U-235.**
  - **Naturally, 99.27% of Uranium exists in form of U-238** while rest in other isotopes as: U-235 (0.72%), and U-234 (0.006%) etc.
  - Most **nuclear reactors** that produce **electricity only require** fuel that is **enriched to between 3-5%** U-235.
- **Highly enriched uranium (HEU)** is anything enriched **above 20% U-235.**

Uranium-241

- **Uranium-241** has been discovered **recently.**
  - It has **atomic number 92 and mass number 241.**
  - It could **have a half-life of 40 minutes.**
- New isotope was **found during** a process **called multinucleon transfer.**
  - In **multinucleon transfer**, two isotopes exchanged protons and neutrons.

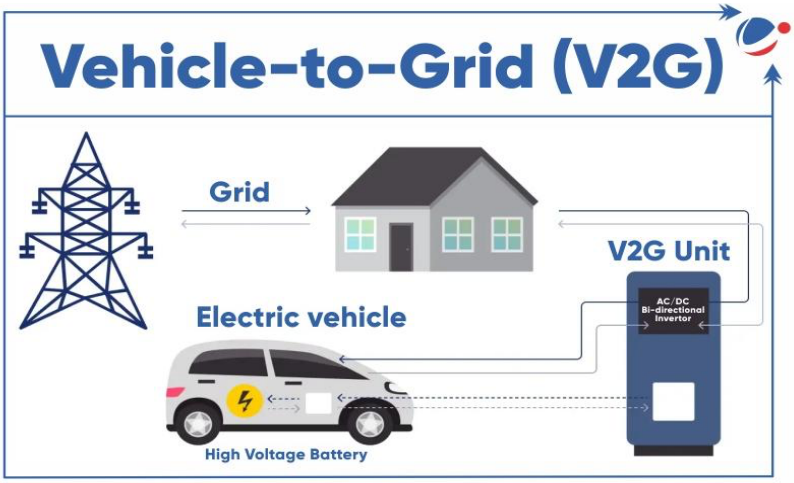
About Advanced Liquid Processing System (ALPS)

- Contaminated Water stored at the **Fukushima Daiichi Nuclear Power Station (FDNPS)** has been released after treating through an **Advanced Liquid Processing System (ALPS).**
- ALPS is a **pumping and filtration system** which uses a series of chemical reactions **to remove radionuclides** from the contaminated water.
- **Prior to being treated by ALPS** system, **contaminated water had caesium and strontium** (account for most of the radioactivity from the contaminated water)**,** removed periodically**.**

5.5. OTHER IMPORTANT NEWS

5.5.1. EV-TO-GRID (V2G) CHARGING

- **Central Electricity Authority (CEA) proposed battery standardization** to boost EV-to-grid charging.
- EV's can provide services to the power system through **smart charging**.
  - **Smart charging** includes bidirectional (sometimes referred to as **reverse charging**) V2G charging.
- **CEA** is established under the **Electricity (Supply) Act, 1948.**
  - It discharges functions under **Electricity Act, 2003, which replaced 1948 Act.**



5.5.2. FISSION MOLYBDENUM-99

- Recently, **Molybdenum-99 production facility** located in Trombay Campus of Bhabha Atomic Research Centre was inaugurated.
- **About Molybdenum-99**
  - Parent **isotope** of **technetium-99m** (Tc-99m).
    - ✓ Tc-99m is a short-lived, gamma-emitting isotope.

- **Tc-99m** is useful for **nuclear medicine procedures.**
  - ✓ Because it can be chemically incorporated into **small molecule ligands and proteins.**
  - ✓ Its production begins with the **neutron irradiation of fissile U-235** contained in highly enriched uranium.

5.5.3. DIRECT METHANOL FUEL CELLS (DMFCS)

- **An alloy of Cobalt and Platinum** doped with Manganese has been found to be **an effective catalyst in DMFCs.**
- **DMFC** is an electrochemical energy conversion device that **directly converts liquid methanol's chemical energy into electrical energy.**
  - DMFCs have a **high energy density**, **high efficiency** and **low operating temperature** and are **safer to operate** as they deal with liquid fuel (methanol).
  - It generates cleaner energy and can utilize all by-products (**except the CO_2)** of the reaction.
  - **Application:** An alternate power source for small vehicles, such as battery chargers for mobile phones, digital cameras, laptops, and other small electronic gadgets etc.

6. DEFENCE

6.1. S-400 AIR DEFENCE SYSTEM

Why in the News?

Indian Air Force deployed S-400 missile units on China and Pakistan border as per reports.

About S-400

- One of the world's most Advanced **air defence system**.
  - **Mobile long-range surface-to-air missile** system developed by Russian State-owned enterprise.
  - **Capability to protect against almost all sorts of aerial attacks**, including drones, missiles, rockets and even fighter jets.
- **Key features**
  - Carries command and control centre, automatic tracking and targeting systems, launchers and support vehicles.
  - Carries separate radar systems which can detect aerial targets to a range of **400 kms (surveillance range up to 600km).**
  - **Simultaneously engages 80 aerial targets.**
  - Can hit target up to **altitude of 30km.**

India's Major Air Defence Systems

- Very Short Range Air Defence System **(VSHORADS), a 4th generation Man Portable system.**
- Prithvi Air Defence system with a range of **300 to 2000 km.**
- Advance Air defense system with a range of **150 to 200 km**.
- **Akash Weapon System**, Short Range Surface to Air Missile System, indigenously designed and developed by DRDO.

Project Kusha

- India is set to deploy its own **Long-Range Surface-to-Air Missiles (LR-SAM) defence system Project Kusha by 2028-29.**
- **About Project Kusha**
  - Project is designated under the purview of the **Defence Research and Development Organization (DRDO)**.
  - Will be **designed to detect and destroy a wide array of threats**, including stealth fighters, aircraft, drones and cruise missiles.
  - Will comprise **three layers** of **surface-to-air missiles**, each designed to engage targets at different ranges capable of hitting at **150, 250, and 350 km.**

Other Air Defence Systems

US' Air Defence Systems

- **Terminal High Altitude Area Defense (THAAD):** US' a one-dimensional missile system which can fire only one type of missile upto a range of 150-200 km and cannot intercept a fighter jet.
- **Patriot Advanced Capability-3 (PAC-3):** Has ability to intercept aerial targets at a range of 180 km.
- **National Advanced Surface-to-Air Missile System (NASAMS):** A highly adaptable combat-proven medium-range air defense solution.

Iron Dome System

- Iron Dome is **Israel's most advanced short-range, ground-to-air, air defence system**.
  - It includes **detection** and **tracking radar, a Battle Management** and **Weapon Control System, and Tamir interceptor missiles**.
  - It can **track and neutralise** any incoming rockets, missiles or Unmanned Aerial Vehicles (UAVs).

David sling Air Defence system

- **Israel** used **David's Sling air-defense system** to intercept Hamas rockets.
- David's Sling system includes a **missile firing unit, a fire control radar, a battle management station,** and **the interceptor**.

- Designed for "**plug and play" insertion into fielded air and missile defence systems** – open architecture.

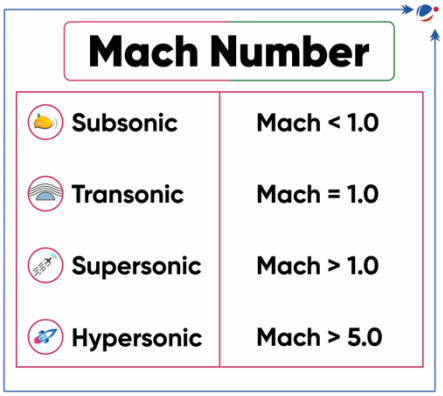
European Sky Shield Initiative' (ESSI)

- **Austria and Switzerland joined** ESSI.
- **ESSI** aims **to create a European air and missile defence system.**

6.2. HYPERSONIC MISSILE

Why in the News?

Iran presented its first domestically made hypersonic Missile named "**Fattah**" having a **target range of 1,400 km.**



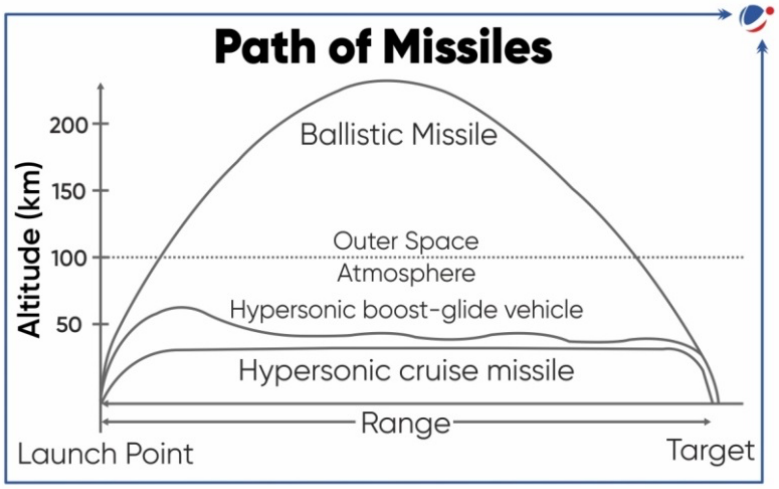
About Hypersonic Missile

- A type of weapon that travels at speeds that exceed five times the **speed of sound typically exceeding Mach 5.**
- Fly at a **much lower altitude** than **conventional ballistic missile.**
- **Types of Hypersonic System**
  - **Hypersonic Glide Vehicles** launched from a **rocket**.
  - **Hypersonic Cruise Missiles, powered by air-breathing high-speed engines** or 'scramjets'.
- **Advantages of Hypersonic Weapons**
  - Use only kinetic energy and energy derived from motion to destroy unhardened targets in underground facilities.
  - Could enable responsive, long-range, strike options against distant, defended, and/or time-critical threats (such as road-mobile missiles).
  - Difficult to detect due to their speed, maneuverability.
- **India's Status:** As part of its **Hypersonic Technology Demonstrator Vehicle program,** India has successfully tested a **Mach 6 scramjet**.
- The **US, Russia, and China lead in hypersonic weapons programs**, while Australia, India, France, Germany, and Japan are also developing such technology.
- Recently, **Russia used an advanced hypersonic missile Zircon** for the first time in recent strike on Ukraine.

Related Development

Endo-atmospheric interceptor missile

- **DRDO successfully conducted** a flight trial of a **sea-based endo-atmospheric interceptor missile**.
  - Missile will be used to **engage a hostile ballistic missile threat**.
- **Ballistic missiles** follows **ballistic trajectory**.
  - **These missiles are powered by rockets initially** but then they follow an unpowered, **free-falling trajectory toward their targets**. Example: **Prithvi, Agni etc.**
  - **Intercontinental ballistic missiles** (**range of over 5,500 km**) exit the Earth's atmosphere.
- **A cruise missile is self-propelled** (till the time of impact) guided vehicle that sustains flight through aerodynamic lift **for most of its flight path**.
  - They **fly within the earth's atmosphere**. E.g.**Brahmos**.



6.2.1. OTHER MISSILES IN NEWS

6.2.1.1. PRALAY BALLISTIC MISSILE

- India successfully test-fire Pralay missile.
- **About Pralay Missile**
  - Developed by **Defence Research and Development Organisation (DRDO)**.
  - **Range**: **150-500 km Short-Range Ballistic Missile (SRBM).**
  - **Type**: Surface-to-surface missile.
  - **Payload capacity:** 500-1,000 kg.
  - Has a **solid-fuel propellant**, based on **Prithvi Defence Vehicle**.

6.2.1.2. ASTRA MISSILE

- Light Combat Aircraft Tejas, has successfully test fired the ASTRA missile.
- **About Astra Missile**
  - **Indigenously Developed by DRDO**
  - Beyond Visual Range Air - to - Air missile
  - Designed to engage and **destroy highly manoeuvring supersonic aircraft.**
  - **All weather day and night capability**
  - Designed to mount on **fighter aircrafts**
  - **Range**: 80-110 kms for version Mk1 and 160kms for version Mk2.
  - **Altitude**: Up to 20 km.
  - **Max Speed**: Mach 4.5

6.2.1.3. SPIKE NON LINE OF SIGHT (NLOS) ANTI-TANK GUIDED MISSILE

- Indian Air Force has received the Israeli Spike NLOS Anti-Tank Guided Missiles.
- Spike NLOS will be **integrated with Russian-origin fleet of Mi-17V5 helicopters**.
- **About Spike NLOS**
  - Belongs to **6th Generation of Spike missiles.**
  - **Capable of destroying enemy targets hidden** behind mountains from long ranges.
  - **Range** is **upto 30km**.
  - **Lightweight, fire-and-forget tactical precision-guided missiles** using electro-optical and fiber-optic technologies.

6.3. DRONES/AIRCRAFTS/SUBMARINES IN NEWS

6.3.1. DRONES/ UNMANNED AERIAL VEHICLE (UAV)

6.3.1.1. TACTICAL AIRBORNE PLATFORM FOR AERIAL SURVEILLANCE-BEYOND HORIZON-201 (TAPAS BH-201)

- **Indian Navy and DRDO** have successfully carried out control capabilities of TAPAS UAV from INS Subhadra.
- Indigenously developed **TAPAS BH-201** (previously Rustom-II) is **a Medium Altitude Long-Endurance (MALE) Unmanned Aerial Vehicle (UAV).**
- Developed by **Bengaluru based Aeronautical Development Establishment (ADE).**

6.3.1.2. AUTONOMOUS FLYING WING TECHNOLOGY DEMONSTRATOR (FWTD)

- DRDO Successfully tests Autonomous FWTD.
- **About FWTD**
  - An **indigenous high-speed flying-wing** Unmanned Aerial Vehicle (UAV).
  - It has a **tailless fixed-wing aircraft** that houses its payload and fuel in its main wings.
  - It is a scaled-down version of its futuristic **unmanned combat aerial vehicle.**

- Designed and developed by DRDO's **Aeronautical Development Establishment.**
- **Significance**
  - ✓ **Allow take-off and landing from any runway** surveyed coordinates (using GPS Aided GEO Augmented Navigation (GAGAN)).
  - ✓ Allows **autonomous landing** without the need for ground radars/infrastructure/pilot.
  - ✓ India joined the elite club to master the **flying wing technology**.
  - ✓ Can be employed as a **covert stealth combat drone**.

6.3.1.3. MQ-9B REAPER

- US has approved sale of **31 US MQ 9B Predator reaper drones** to India**.**
- **About MQ-9B Reaper**
  - Drones that are **designed to fly over the horizon via satellite** for over 30 hours.
  - **Safely integrate into civil airspace,** enabling joint forces and civil authorities to deliver real-time situational awareness.
  - **Integrates advanced maritime intelligence**, surveillance, and reconnaissance (ISR) capabilities
  - **Enables real-time search** and patrol above and below the ocean's surface.
- Also, Indian Navy has planned to equip **MQ 9B SeaGuardian** with Sonobuoy (small device used for **underwater acoustic surveillance**).
- The MQ-9B has two variants — **the SkyGuardian and the SeaGuardian**, its maritime variant.

6.3.2. AIRCRAFT/HELICOPTERS

6.3.2.1. MH-60R ROMEO HELICOPTER

- The Indian Navy has received the sixth MH-60R "Romeo" helicopter from US.
- **About MH-60R helicopter**
  - Manufactured by Lockheed Martin Corporation.
  - **All-weather helicopter** designed to support multiple missions with **state-of-the-art avionics and sensors**.
  - **Key Features**: **Anti-Submarine Warfare** (ASW), **surveillance, anti-shipping, and search** and **rescue capabilities.**

6.3.2.2. DHRUV ADVANCED LIGHT HELICOPTER

- A government **regulatory body has called for a safety upgrade** of the Dhruv helicopter.
- **About Dhruv helicopter**
  - A **multi-role, multi-mission new generation helicopter.**
  - Certified for both civil and military roles.
  - **Indigenously designed** and **developed** by **Hindustan Aeronautics Limited**.
  - **Capable of operating in all-weather conditions** and powered by **twin shakti engines.**

6.3.2.3. LIGHT COMBAT AIRCRAFT (LCA) TEJAS

- **LCA Tejas has completed seven years of service** in the Indian Air Force.
- **About LCA Tejas**
  - **A 4.5 generation, all weather** and **multi-role fighter aircraft.**
  - Capable of taking up **offensive air support, close combat and ground attack role at ease.**
  - Designed by Aeronautical Development Agency (ADA) and produced by Hindustan Aeronautics Limited (HAL).
  - **Key characteristics**: Smallest & lightest aircraft in its class; In Flight Refueling (IFR) Probe; and Equipped with state-of-the-art Satellite aided Inertial Navigation System.

6.3.2.4. LIGHT COMBAT HELICOPTER (LCH) PRACHAND

- Army successfully test-fires rocket and turret guns of indigenous LCH Prachand (**means fierce**).
  - It was **inducted into Indian Air Force in 2022**.
- **About Prachand**
  - LCH **Prachand** is a indigenously developed **multi-role combat helicopter.**
  - It was **designed and developed** by **Hindustan Aeronautics Ltd.**
  - **Only attack helicopter in the world** that can **land and take off** at an **altitude of 5,000 metres**.
  - Capable of firing **air-to-ground and air-to-air missiles**.
  - **Fitted with 5.8-tonne twin-engine named Shakti engine**, primarily designed for deployment in high-altitude areas (like Siachen glacier).

6.3.3. SUBMARINE/SHIPS

6.3.3.1. PROJECT 75 (INDIA) [P75 (I)]

- **P75 (I**), succeeds P75, is part of **30-year submarine building plan** that ends in 2030
  - P75 (I) **requires** Indian bidder to **tie up with a foreign collaborator**.
  - Project 75 is one of two lines of submarines, other being P75I, as **part of a plan for indigenous submarine construction with technology taken from overseas firms.**
    - ✓ Under P75, Kalvari, Khanderi, Karanj, Vagir and Vela have been commissioned.
- P75 (I) envisages **construction of six conventional submarines** with better sensors and weapons and **Air Independent Propulsion System (AIP**).

6.3.3.2. INS IMPHAL

- **INS Imphal is** the third of four **indigenous Visakhapatnam class stealth-guided missile destroyers** under **project 15B**.
  - **Project 15B** is the latest in the lineage of **Project 15A (Kolkata class) and Project 15 (Delhi class)**.
  - The other two destroyers of this Project are **INS Visakhapatnam** and **INS Mormugao.**
- Designed by the Indian Navy's **Warship Design Bureau** and constructed by **Mazagon Dock Shipbuilders** Limited (MDL), Mumbai.
- **Armed with** medium-range surface-to-air missiles, **Brahmos** surface-to-surface missiles, **Indigenous torpedo launchers** etc.
- Recently, **Mahendragiri** frigate was commissioned; it is a **part of Project 17A (Niligiri class).**
  - **Project 17A Frigates are the follow-on class of the Project 17 (Shivalik Class) Frigates,** with improved stealth features, advanced weapons & sensors and platform management systems.
  - Project 17A ships have been designed in-house by **Indian Navy's Warship Design Bureau.**

6.4. OTHER IMPORTANT NEWS

6.4.1. DHANUSH ARTILLERY GUNS

- Dhanush is a **155 mm, 45-calibre towed artillery gun.**
- **Range:** Demonstrated a range of around 38 km with specialized ammunition.
- First **indigenously** built long-range artillery gun.
- **Features**
  - Equipped with an **inertial navigation-based sighting system**, auto-laying facility.
  - **Onboard ballistic computation**, an advanced day-night direct firing system.
  - **Consists of Self-propulsion unit that** allows the **gun to deploy itself** in the field.

6.4.2. CLUSTER BOMBS

- USA has decided to supply Ukraine with cluster bombs as a part of new military aid package.

- Cluster bombs (**Cluster Munitions**) are **canisters that carry tens to hundreds of smaller bomblets**, also known as **sub-munitions.**
  - These canisters can be **dropped from aircraft, launched from missiles or fired from artillery, naval guns or rocket launchers.**
  - Canisters **break open at a prescribed height**, depending upon the area of intended target.
  - They are **fused by a timer to explode** closer to or on the ground.

6.4.3. NEERAKSHI

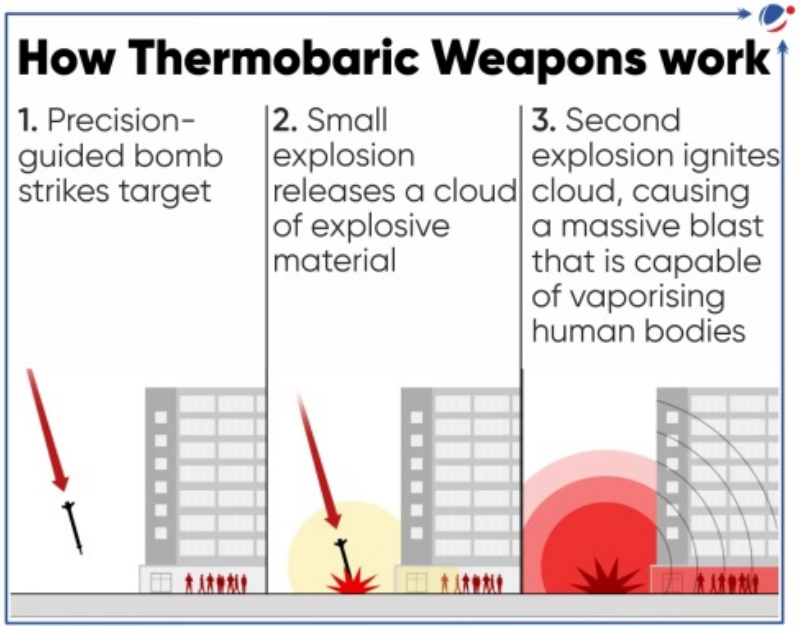
- **India launched its first** of its kind **Autonomous Underwater Vehicle (AUV)** named **'Neerakshi.**
  - Can be used for **mine detection, mine disposal, underwater surveys** etc.
  - Has an **endurance of four hours** and can go **up to 300 metres deep.**
- Developed in collaboration of **Garden Reach Shipbuilders and Engineers (GRSE) Ltd** and MSME entity **Aerospace Engineering Private Ltd (AEPL).**

6.4.4. VARUNASTRA

- Varunastra was successfully test-fired with a live warhead against an undersea target, by the Indian Navy.
- Indigenous **ship-launched anti-submarine torpedo.**
- Designed and developed by **Vizag-based Naval Science and Technological Laboratory (NSTL)** under the **DRDO** and is manufactured by Bharat Dynamics Ltd (**BDL**)
- **Features**: Maximum speed of **40 knots** and a maximum **operating depth of 600 m**, has a long range with **multi-manoeuvering capabilities.**

6.4.5. THERMOBARIC BOMB

- Human rights group accused **Myanmar's military of using thermobaric bomb.**
- **About Thermobaric bomb**
  - Also known as **vacuum or aerosol bomb** - or fuel air explosive.
  - **Consists** of a fuel **container with two separate explosive charges**.
    - ✓ When it hits its target, **first explosive charge opens the container and widely scatters fuel** mixture **as a cloud.**
    - ✓ **A second charge then detonates the cloud, resulting in** a huge fireball, a massive blast wave and **a vacuum which sucks up all surrounding oxygen.**



6.4.6. PROJECT SANJAY

- The army under 'Project Sanjay' is working on creating **battlefield surveillance system** for composite operational picture.
- Project Sanjay seeks **to create multiple surveillance centres for the field formations and enable the integration of a large number of sensors.**

7. AWARDS AND PRIZES

7.1. NOBEL PRIZE IN PHYSICS 2023

Prize awarded for: Experimental methods that generate **attosecond pulses of light** for the study of **electron dynamics in matter.**

Awardees: Pierre Agostini, Ferenc Krausz, and Anne L'Huillier (**only the fifth woman to win a Nobel Prize in Physics**).

About Electron Dynamics

- **Electron dynamics** is the behaviour **and movement** of electrons within **atoms and molecules.**
- **Atoms can move** and **turn** in millionths of a billionth of a second, known as **femtoseconds** (10^{-15} second).
  - For a long time, femtosecond was seen as the shortest achievable duration of the light pulses
- **Electrons move or change rapidly,** in the **magnitude of attosecond**, which makes them difficult to study.
  - An attosecond is equivalent to $1*10^{-18}$ of a second.

How did the discovery overcome this challenge?

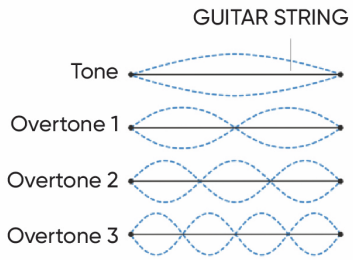
Generation of attosecond pulses of light (Anne L'Huillier)

- Anne L'Huillier and her colleagues transmitted an Infrared laser beam through a noble gas and it produced **multiple overtones**.
  - Led to creation of **shorter pulses of light than were previously possible.**
  - Produced light pulses for a few hundred **attoseconds** with the help of **interference.**
    - ✓ It included

Overtones

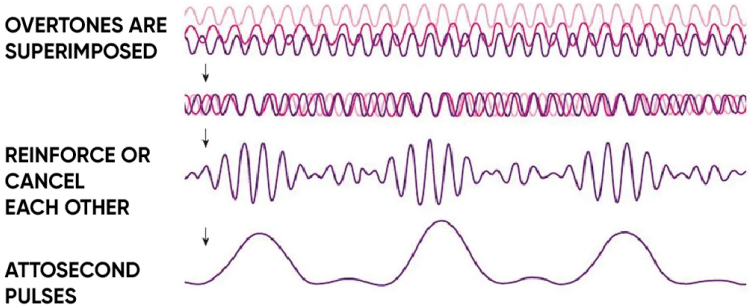
- They are **waves of light whose wavelength was an integer fraction** of the beam.
- **For example,** if the beam had a wavelength of 100, the overtones would have wavelengths of 10, 25, 50, etc.

Overtones have several cycles for each cycle in the fundamental tone. Overtones work the same way in light waves.

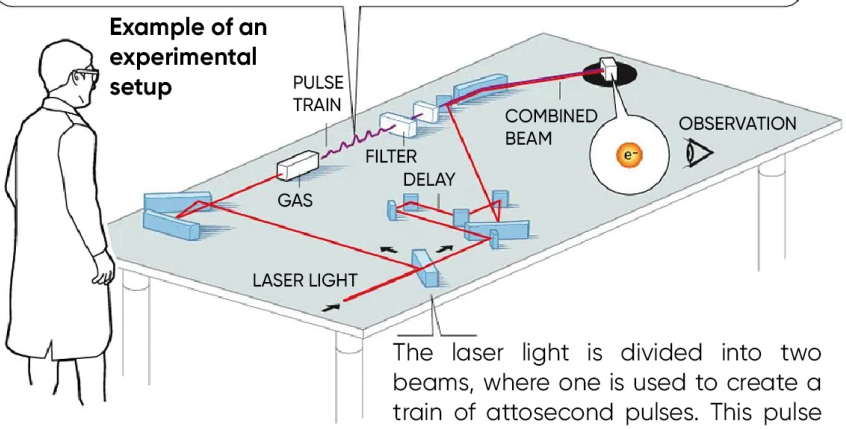


The world of electrons is explored with the shortest of light pulses

When laser light is transmitted through a gas, ultraviolet overtones arise from the atoms in the gas. In the right conditions, these overtones may be in phase. When their cycles coincide, concentrated attosecond pulses are formed.



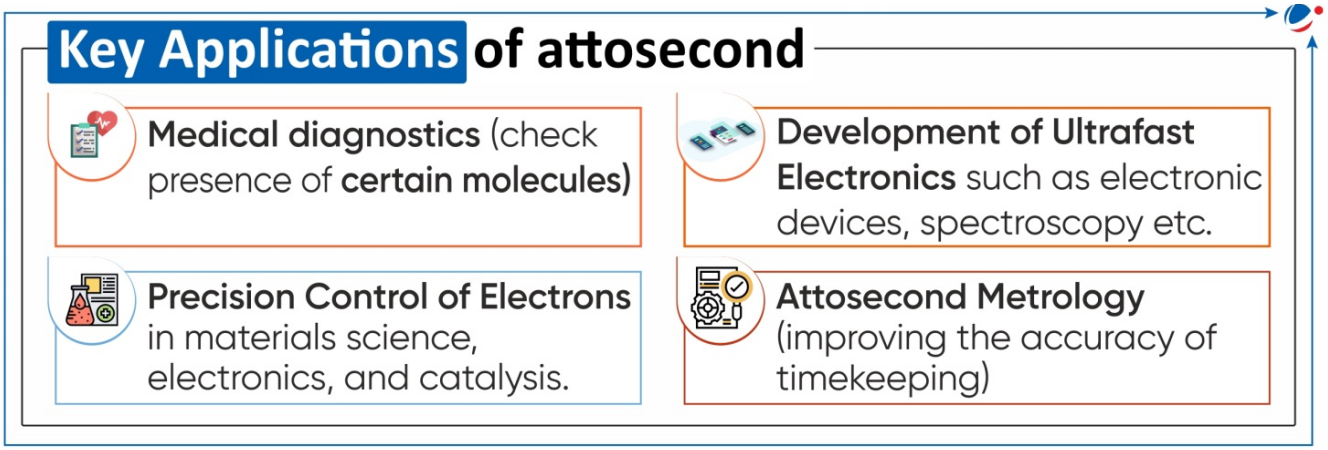
Example of an experimental setup



The laser light is divided into two beams, where one is used to create a train of attosecond pulses. This pulse train is then added to the original laser pulse and the combination is used to perform extremely rapid experiments.

- **Constructive interference** (merges with the peak of another)
- **Destructive interference** (peak of one overtone merges with the trough of another).

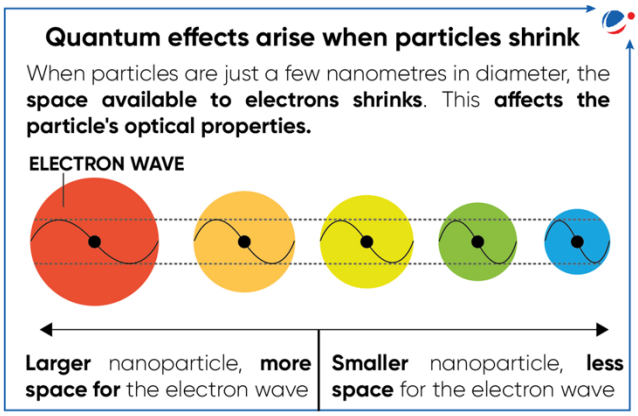
- **Production of pulse train (Pierre Agostini and Ferenc Krausz)**
  - They were able to produce **verified attosecond pulses in a 'train'**, a pulse followed by a gap, followed by a pulse, and so forth.
  - Produced a **pulses as short** as **of 43 attoseconds.**
  - **These pulses can be used to provide images** of the processes inside atoms and molecules.



7.2. NOBEL PRIZE IN CHEMISTRY 2023

Prize awarded for: Discovery and development of **quantum dots.**

Awardees: **Moungi G. Bawendi, Louis E. Brus** and **Aleksey Yekimov.**

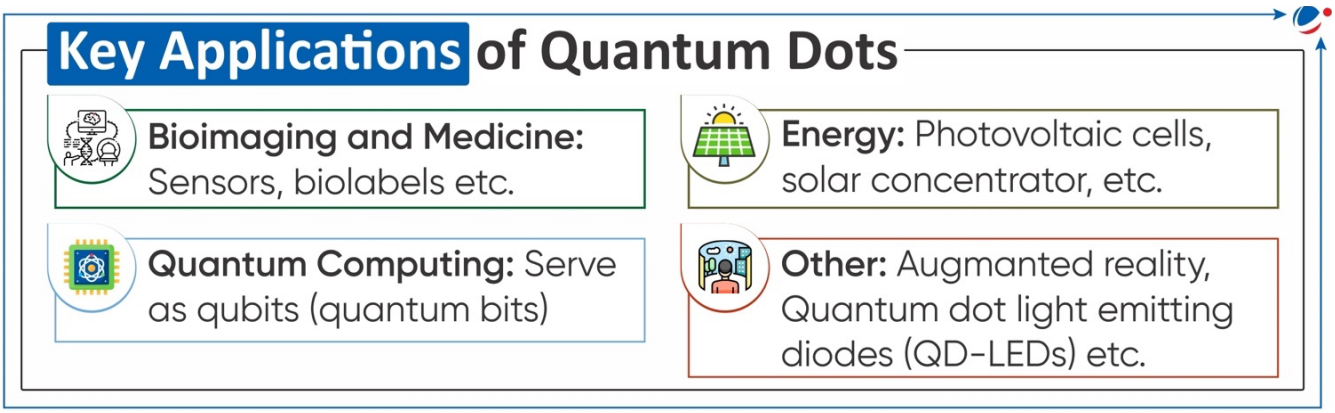


About Quantum Dots (QDs)

- A **man-made semiconductor particles** or **crystal**, size is normally not more than **10 nanometers.**
  - At the nano scale, material show new distinct properties because of quantum physical forces.
  - Denoted **as artificial atoms** or **zero-dimensional electron systems.**
- **Properties of QDs:** They exhibit **quantum confinement** (particles confined to a very small space), which leads to many unique optical and transport properties.
  - **Fluorescence:** On exciting, emits photons of a specific wavelength.
  - **Tunable Emission:** Emit light of **different colours depending on their size**. This property is called **size-tunable emission.**
  - **Photostability:** Less prone to **photobleaching** (loss of fluorescence over time)**.**
  - **Material Variety:** Made from different semiconductor materials.
    - ✓ It may be **cadmium selenide (CdSe), lead sulfide (PbS),** and **Indium arsenide (InAs)**.
  - **Biocompatibility:** Used in **biological applications** without causing harm to **living cells.**

About Nobel Winning Research

- **Alexei Ekimov** succeeded in creating **size-dependent quantum effects** in **coloured glass.**
- **Louis Brus** was the first scientist in the world to prove size-dependent quantum effects in **particles floating freely in a fluid.**
- **Mungi Bawendi** developed a technique to make QDs of well-defined sizes and with high optical quality.



7.3. NOBEL PRIZE IN PHYSIOLOGY OR MEDICINE 2023

Prize awarded for: Discoveries concerning nucleoside base modifications that enabled the development of **effective mRNA vaccines against COVID-19.**

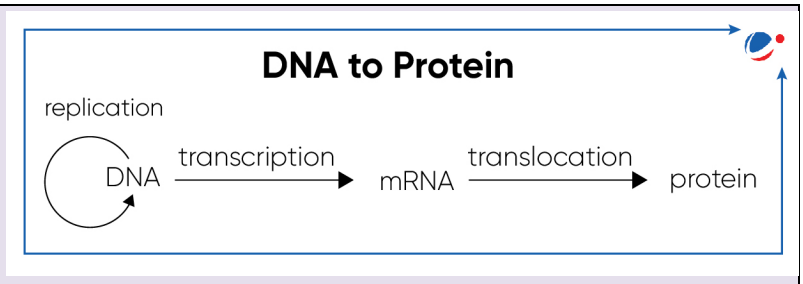
Awardees: The prize was given to **Katalin Karikó** and **Drew Weissman**.

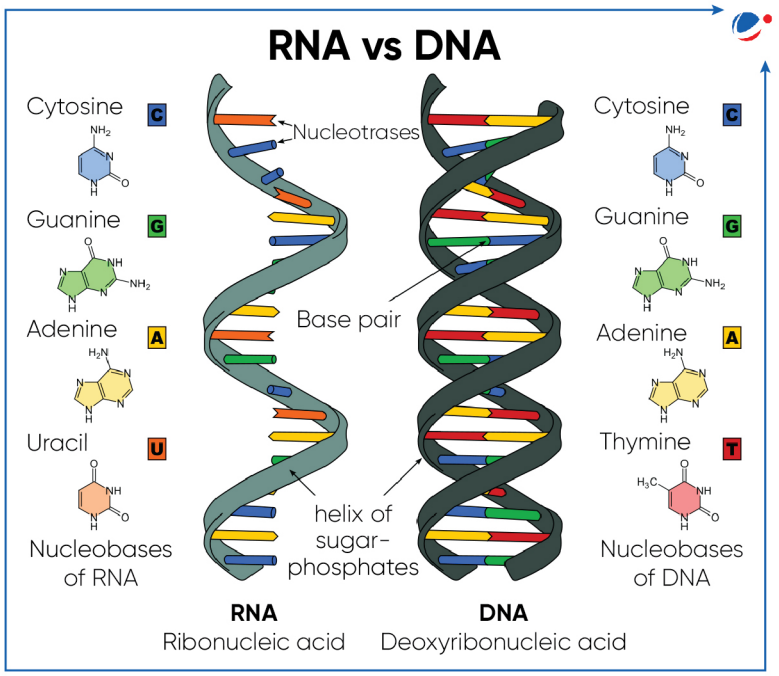
About mRNA
(messenger Ribonucleic Acid)

- **DNA stores all the genetic information** in our bodies; **mRNA carries that genetic information**, similar to a blueprint or set of instructions, that is then **translated into proteins.**
  - **RNA contains 4 nucleoside bases**, abbreviated A, U, G, and C, corresponding to A, T, G, and C in DNA, the letters of the genetic code.

Working of an mRNA vaccine

- mRNA vaccines use mRNA created in a laboratory to teach **our cells how to make a protein**-or even just a piece of a protein that **triggers an immune response** inside our bodies.
  - **In vitro transcribed mRNA or synthetic mRNA** is the synthetic form of mRNA that is used in mRNA-based vaccines. (It is created outside of a living cell.)
- This immune response, which **produces antibodies**, is what helps protect us from getting sick immediately.
  - Also, the body remembers the associated pathogens, thus creating immunity for the future.

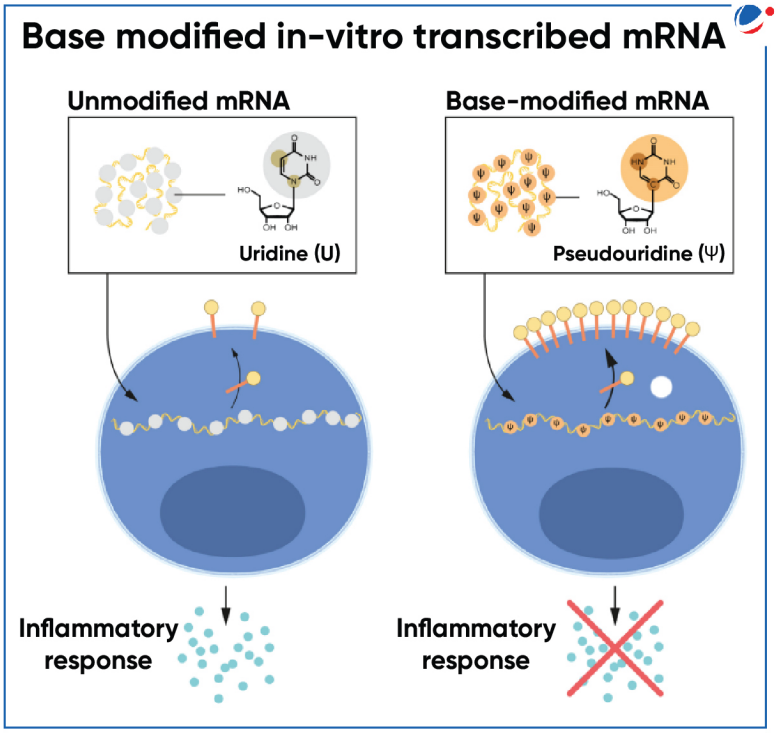




The mRNA vaccines provided a promise of faster vaccine development but posed significant challenges. These challenges were addressed in the work of Nobel Laurates.

Work of Nobel laureates

- **Understanding the concerns with mRNA vaccines**
  - **Issues with In vitro transcribed mRNA vaccines:**
    - ✓ **Instability**: They were considered **unstable** and **challenging to deliver**, requiring the **development of sophisticated delivery systems**.
    - ✓ **Inflammatory reactions**: The cells **recognize in vitro transcribed mRNA as a foreign substance,** which leads to their activation and the release of **inflammatory signaling molecules.**
    - ✓ **Inefficient protein production** in cells and tissues.
  - They questioned why this **synthetic mRNA was considered to be a foreign substance** while mRNA from mammalian cells did not give rise to the same reaction.
    - ✓ **Reason for a different reaction:** The mRNA from cells (mammalian mRNA) undergoes a chemical change after entering the body, whereas the synthetic mRNA remains unchanged.
  - This led them to realize **some critical properties** must distinguish **synthetic mRNA** from **mammalian cells mRNA.**
- **Breakthrough by them**
  - **Understanding**: Karikó and Weissman knew that **nucleoside bases in RNA from mammalian cells are frequently chemically modified**.
  - **Hypothesis**: They hypothesised that the **absence of altered bases** in the in vitro transcribed RNA could explain the **unwanted inflammatory reaction**.
  - **Testing**: On testing, they produced different variants of mRNA, each with unique **chemical alterations in their bases**, which they delivered to the cells.
  - **Result**: The results were significant as the **inflammatory response was almost abolished** when base modifications were included in the mRNA.



Applications of the discovery

- Can be used to develop Vaccine at an unprecedented pace and have broad applicability.
  - E.g., mRNA vaccines developed by **Pfizer/ BioNTech and Moderna.**

Major Covid Related Vaccine in India

- **ZyCoV-D-** World's 1st and India's indigenously developed DNA Vaccine.
- **CORBEVAXTM**-India's first protein subunit vaccine.
- **GEMCOVAC** - World's 1st and India's indigenously developed mRNA vaccine.
  - **GEMCOVAC-OM** is a lyophilized (freeze dried) vaccine, is delivered using a device called Tropis, deliver vaccines through the skin without utilising needles.
- **iNCOVACC-**World's 1st and India's indigenously developed intranasal COVID-19 Vaccine.

Related Development/Concepts

micorRNA (miRNA)

- A recent study in US showed a miRNA called **'let-7'** is **crucial for fighting cancer.**
- miRNAs are small, highly conserved **non-coding RNA molecules**.

- **Controls gene expression** by binding target mRNA (messenger RNA) to prevent protein production.
- Found in most **eukaryotes**, including humans. miRNA account for **1-5% of the human genome and regulate at least 30% of protein-coding genes.**
- Also, for the first time, researchers have sequenced RNA from any extinct species (Tasmanian Tiger).
    - It will help in getting information about metabolism regulation of species and helping in understanding reason behind extinct.

Immune imprinting

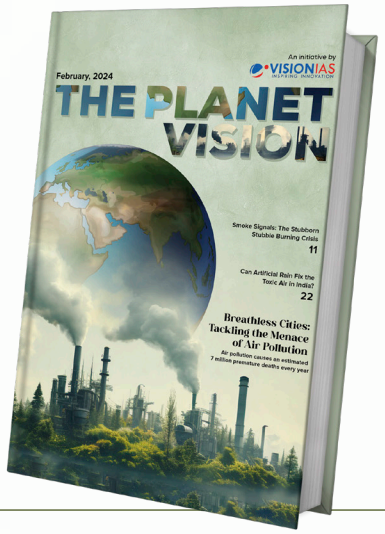
- A study has been conducted to understand the occurrence of **immune imprinting** in the **antibody responses** of the host to severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2).
- **Immune imprinting** is a tendency of the body to **repeat** its **immune response based** on the first variant it encountered through infection or vaccination.
    - It happens when it comes across a newer or slightly different variant of the same pathogen.

RNA interference (RNAi)

- RNAi is a natural process by which cells **use short, double-stranded RNAs (dsRNAs)** to **recognize messenger RNAs (mRNAs)** with exquisite specificity.
- It leads to their enzymatic destruction and preventing their translation into a protein.
- Therefore, they inhibit gene function.

VISIONIAS
INSPIRING INNOVATION

THE PLANET VISION



In a world facing unprecedented environmental challenges, staying informed and empowered is more crucial than ever. VisionIAS brings you **'The Planet Vision'**, a simplified, informative, and interactive magazine to delve into the complexities of the environment.

With the belief, that individual efforts and awareness are the key to a sustainable future, the magazine seeks to inspire and educate people to **develop a deeper understanding and appreciation for the environment, nature & planet.**

Objectives of 'The Planet Vision'

- **Sensitise the young generation:** Highlighting pressing environmental issues and their multifaceted impacts.
- **Inspire Action and Promote Sustainable Lifestyle:** Inspiring stories and case studies to motivate readers to make environmentally conscious choices.
- **Bridge Environmental Science and Public Understanding:** Presenting complex scientific concepts in a simple and interactive manner.
- **Showcase Solutions:** Spotlight innovative technologies, projects, and initiatives that offer solutions to environmental challenges.
- **Highlight Local Efforts:** Showcase local conservation efforts, community initiatives, and grassroots projects that make a positive impact on the environment.

Who is the magazine for?

The Magazine is designed for students, eco-conscious individuals, educators, environmentalists, and anyone who cares about the health of our planet.

Key elements of the 'The Planet Vision'

- **Cover Stories:** Thought-provoking articles about a critical ongoing environmental issue, along with the mitigation strategies adopted at the national and international levels.
- **Briefing and Developments:** Stay informed about the latest environmental news, trends, and solutions.
- **Protect and Preserve:** Inspirational stories of local conversation efforts.
- **Environment and You:** Illustrating ways to make environmentally conscious choices in everyday life.
- **Green Tech:** New and emerging technologies in the field of environment.
- **Interactive elements:**
  - **Snapshot:** Telling a story through capturing images.
  - **Quizzes and crosswords:** To test your understanding and knowledge as a reader.

"Look deep into nature, and then you will understand everything better."
-Albert Einstein

Scan the QR code, to download and read the Magazine:

8. MISCELLANEOUS

8.1. RARE HIGGS BOSON DECAY

Why in the News?

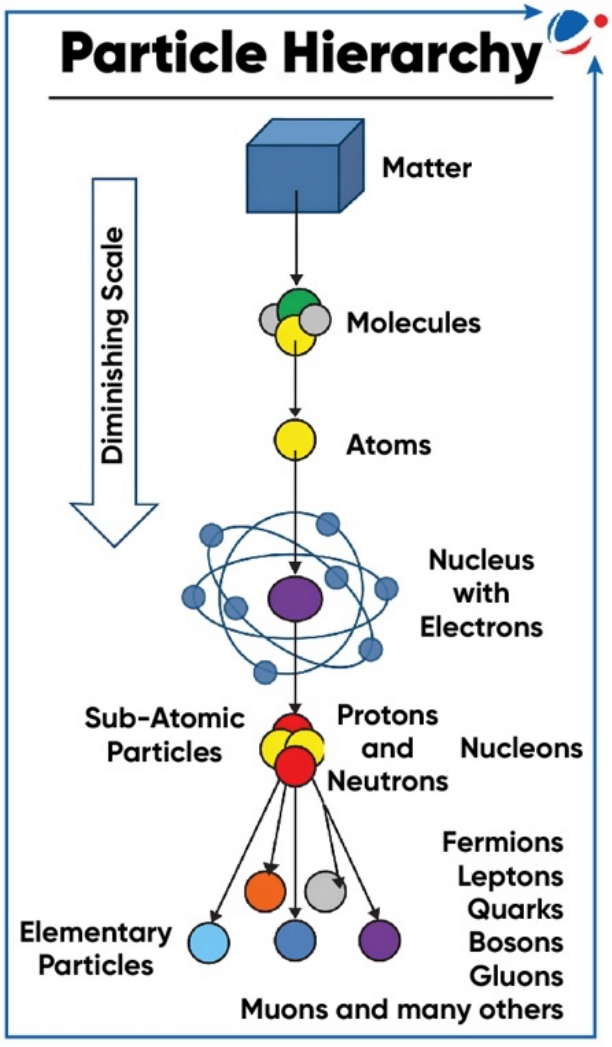
Scientists at **The European Organization for Nuclear Research (CERN)** which hosts the **Large Hadron Collider (LHC)** have discovered evidence of the Higgs boson decaying into Z boson and a photon.

About Large Hadron Collider (LHC)

- **World's largest** and **most powerful particle accelerator**.
- Set up at CERN near Geneva.
- **Consists of superconducting magnets** to boost the energy of the particles.
- **Particle beams travelling close to the speed of light are collided** inside the LHC.

About the discovery

- This is a **very rare decay process** that tells us important things about the Higgs boson as well as about our universe.
- **The decay was reported in the ATLAS and CMS,** general-purpose detectors of the Large Hadron Collider (LHC) of CERN.
- **Implications of the discovery**
  - **Provide indirect evidence to the existence of particles beyond those predicted by the Standard Model of particle physics.**
  - Can **lead to a fifth fundamental force, which is yet to be discovered**.
  - Physicists **currently recognise four fundamental forces namely the strong force**, the weak force, the electromagnetic force and the gravitational force.



About CERN (1954)

- Researchers at CERN are probing **fundamental structure** of the universe and study basic constituent of matter.
- **India is its associate member.**

Higgs Boson

- A **subatomic particle** that was first theorized in the 1960s by physicist Peter Higgs and others.
  - Also, known as God particle.
- Carries the **force that a particle experiences when it moves through an energy field**, called the Higgs field.
  - **For example**, when an electron interacts with the Higgs field, the effects it experiences are said to be due to its interaction with Higgs bosons.
- **Properties of Higgs Boson:**
  - **Mass: 125.35 giga-electron volts (GeV)**
  - **Spin: Scalar particle and has '0' spin**, and do not possess angular momentum.
  - **Lifetime: Very short** and it **rapidly decays into other particles Detection**.
    - ✓ It **normally decays into pairs of photons or pairs of W or Z bosons**.
    - ✓ Recent discovery has found the Higgs Boson decaying with a photon and Z boson.

What is the standard model of particle physics?

- Contains **12 fundamental matter particles categorized as quarks** (which make up protons and neutrons) and l**eptons** (which include electrons).
- Explains how **force carrying particles**, which belong to a **broader group of bosons**, **influence quarks and leptons.**
- Also explains the three of the four fundamental forces of nature i.e except that of Gravitational force.
  - The three forces are as follows Electromagnetism, Strong force, and Weak force.

Related Development

Chiral Bose Liquid

- Physicists from the **USA** and **China** have claimed the discovery of a completely new state of matter namely **Chiral Bose Liquid State**.
- Researchers **discovered the Chiral-Bose liquid state in the super-small quantum scale** by bringing two layers of a special material very close together at very low temperatures (close to absolute zero).
  - ✓ Researchers created a **"frustration machine," a bilayer semiconducting** device designed to create this state of matter.
- In this "quantum" states of matter, matter behaves in ways quite different from the solid, liquid, gaseous states. Particle interactions within these states can give rise to infinite possibilities.
  - Particle interactions within this state **can give rise** to **infinite possibilities**.

Nanophotonic Electron Accelerator (NEA)

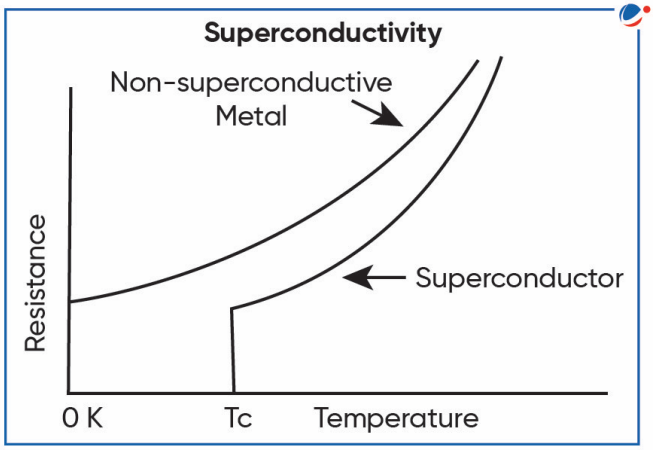
- Scientists fired up Nanophotonic Electron Accelerator (NEA), world's smallest particle accelerator.
- **About NEA**
  - Consists of a **small microchip containing an even smaller vacuum tube** which is made up of thousands of individual pillars.
    - ✓ Main goal is to **utilise the energy given by accelerated electrons in targeted medical treatments for cancer.**
  - **NEA is similar to LHC** as both create a **magnetic field to accelerate particles.**
- **Particle accelerator** is a device that **speed up charged particles, (protons or electrons), at high speeds, close to speed of light.**
  - They are then **smashed either onto a target** or against other particles circulating in opposite direction.

8.2. SUPERCONDUCTIVITY

Why in the news?

Recently, the claims of material **LK-99 depicting the room temperature superconductivity** proved inconsistent.

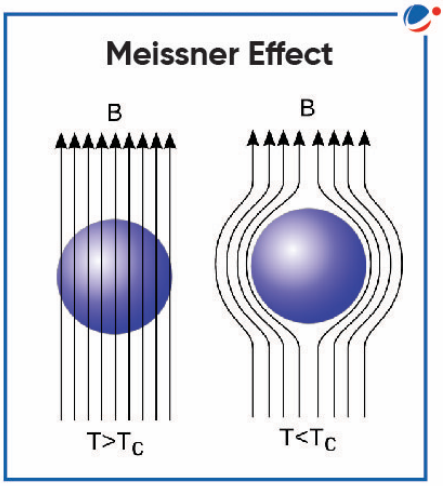
Superconductivity



- **A phenomenon** in which **certain materials** exhibit zero **electrical resistance** and the expulsion of magnetic fields when cooled below a critical temperature (Tc).
  - At T_c the **materials suddenly change** from a **normal conducting state to a superconducting state.**
  - **Meissner Effect** is the expulsion of a magnetic field from a superconductor during its transition to the superconducting state when it is cooled below the Tc.
- Discovered by **Heike Kamerlingh Onnes** in 2011.
- Currently, **superconductivity** can be achieved only at very low temperatures, **more than 250 degrees Celsius below zero.**

- **E.g. Mercury, Lead, Aluminum, Tin, Niobium**, etc.

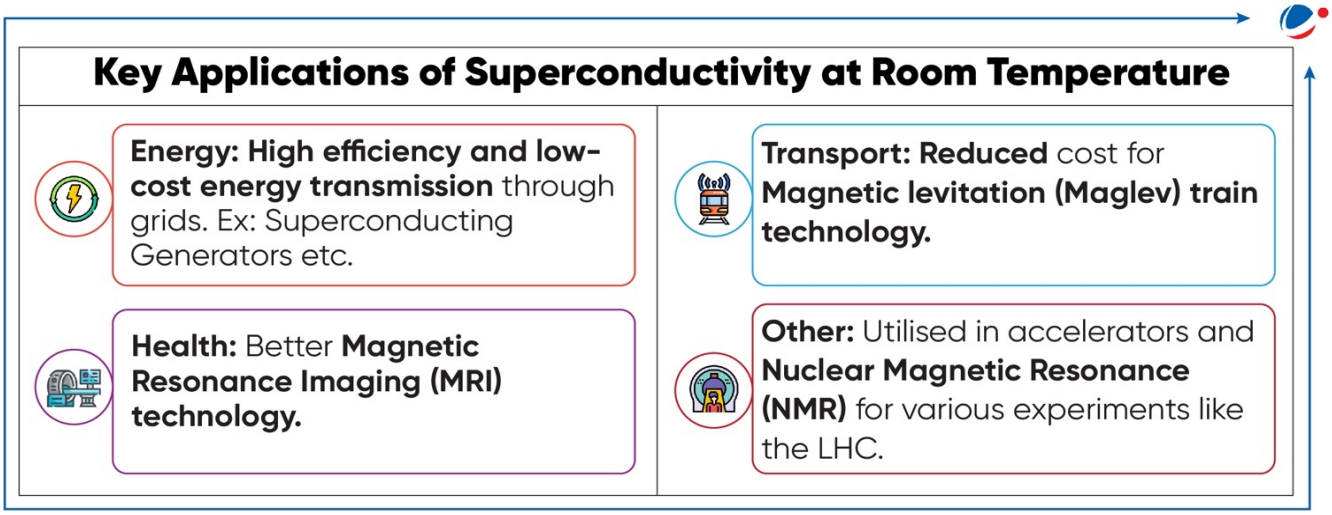
- **How is the zero resistance achieved?**
  - Under normal conditions, electrons encounter resistance when moving through a crystalline solid due to interactions with vibrating atoms in the crystal lattice.
  - However, in certain materials, when the temperature is lowered below a **critical level**, **electrons pair** up into loosely bound pairs known as **Cooper pairs**.
  - The individual electrons within a Cooper pair cannot be easily scattered by the lattice vibrations, and hence, passing electrons start to glide through the material unimpeded, leading to superconductivity and zero resistance.



Superconductivity at Room Temperature

- A room-temperature superconductor is a material capable of exhibiting superconductivity at operating temperatures, i.e. above 0 °C (273 K; 32 °F) - temperatures.
- **Obtaining room temperature superconductivity is affected by many aspects**, like
  - **Difficult to achieve conditions like extreme pressure conditions**, and materials may not be able to withstand these extreme conditions.
  - **Non-formation of Cooper Pairs** at higher temperatures.
  - At room temperature, **thermal energy is relatively high**, making it difficult for electrons to form Cooper pairs and overcome this energy barrier.

Room-temperature superconducting could lead to **more efficient power for quantum computers.** (For other applications see infographic)



Related Development
Semiconductor

- Ministry of Electronics and IT committee recommends setting up the India Semiconductor Research Centre (ISRC).
- **About Semiconductor**
  - A substance that has **specific electrical properties** that enables it to serve as a foundation for computers and other electronic devices.
  - It shows properties between the conductor and insulator.
  - A diode, integrated circuit (IC) and transistor are all made from semiconductors.
  - **Types**:
    - ✓ N-type semiconductor carries current mainly in the form of **negatively charged electrons.**
    - ✓ P-type semiconductor carries current predominantly as electron deficiencies called **holes**.

- **The elemental semiconductors** are those composed of single species of atoms, such as silicon (Si), germanium (Ge), tin (Sn) etc.
- **Compound semiconductors** are composed of two or more elements. For e.g. Gallium arsenide (GaAs).

8.3. RARE EARTH ELEMENTS (REE)

Why in the News?

Hyderabad-based **National Geophysical Research Institute** has found **large deposits of 15 Rare Earth Elements (REE) in Andhra Pradesh's Anantapur district.**

About Rare Earth Elements (REE)

- REEs (also known as **rare earth oxides)** are a group of **17 silvery-white soft heavy metals** that occur together in periodic table.
  - Group consists of **Scandium & yttrium and 15 lanthanide elements** (lanthanum, cerium, praseodymium, neodymium, promethium, samarium, europium, gadolinium, terbium, dysprosium, holmium, erbium, thulium, ytterbium, and lutetium).
  - REEs are **all metals having many similar properties**, and that often causes them to be **found together in geologic deposits**.
- **Applications**: **High end technology, defence applications, electronic devices** like cell-phones, computers, clean energy, electric vehicle etc. because of their luminescent and catalytic properties.
- In similar development, scientists from Institute of Minerals and Materials Technology, Bhubaneswar, have estimated the **quantity of REEs that can be recovered from Red Mud.**
- Red Mud is a **toxic byproduct of aluminium extraction from bauxite ore** using **Bayer process.**
  - **Red Mud contains REEs.**
  - There are **two strategies** to recover REEs from red mud: **extract only REEs or extract all metals** (such as iron, titanium, and sodium) **including REEs.**

8.3.1. VANADIUM

Why in the news?

Geological Survey of India (GSI) discovered vanadium from the Gulf of Khambhat in Gujarat.

More about news

- **Titanomagnetite** is a **primary source** of the element (88% of the world's vanadium is extracted from it) and is formed when molten lava cools rapidly.
- First report of vanadium **occurrence in the offshore sediments of India**.

About Vanadium

- Symbol "V" and the atomic number 23.
- Classified as a **transition metal.**
  - **Transition metal** serves as a bridge or transition between the two sides of the periodic metal.

Reserves of Vanadium

Globally

- **Brazil is the world's largest exporter of vanadium** (one-fourth of total exports).
- Followed by Russia and South Africa.
- **China** has **the highest vanadium reserves and production** (2022).

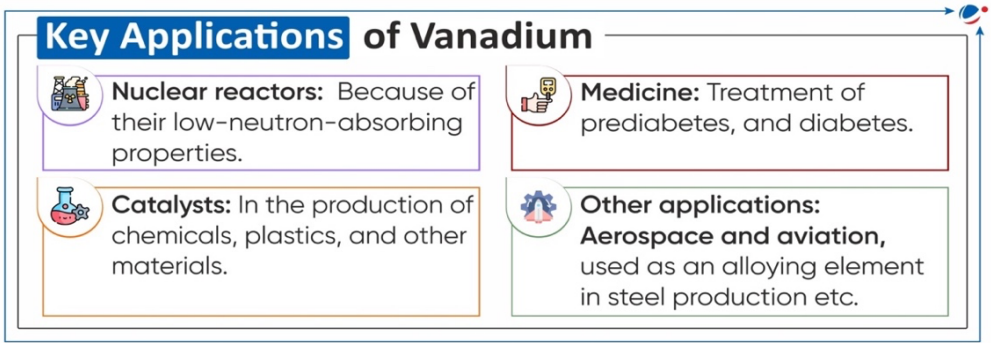
In India

- **Karnataka, Maharashtra and Odisha** are major states with vanadium reserves.
- In 2021, vanadium reserves were also found in **Arunachal Pradesh.**

About Vanadium Redox Flow Batteries (VRFB)

- A type of **rechargeable flow battery** that employs **vanadium ions as the active materials.**
- **Working Mechanism:**
  - Store their energy in two electrolyte tanks, which are connected to a stack of cells.
  - Vanadium has the unique characteristic of having four different stages of oxidation.
  - In each of the four stages, it contains a different electrical charge and is therefore used as a catalyst to store energy.
- **VRFB have lower energy density** (amount of energy compared to its weight) **than Lithium-ion batteries.**
- It has longer life span. It is suitable for **large scale industrial-scale operations.**
- **Initial** installation cost is **higher.**

- Listed as one of the **30 critical minerals**, identified by India.
- **Abundant element** in the **earth's crust**.
- **Occurrence:** Rarely exists as **a free element in nature.**
  - Found in about 65 different minerals, including magnetite, vanadinite, carnotite, and patronite.
  - Can be detected by spectroscopically in the Sun's rays and occasionally in the light of other stars.
  - Also, **present in bauxite, fossil fuel deposits**, in small percentages **in meteorites** etc.
- Vanadium is **recovered from slag that is collected from the processing of vanadiferous magnetite** ore where iron and steel are the principal products.
- It is also **concentrated in many end-products of organic material** including coal, crude oil, oil shale and tar sands.
- It has the **property to increase the tensile strength of steel** and its high strength to weight ratio supports fuel efficiency mandates in the Automotive and Aerospace Industries.



- **Physical Properties:**
  - Hard and **silvery-grey metal.**
  - **Ductile** (can be drawn into wires), **malleable** (can be hammered into thin sheets), and **resistant to corrosion**.
  - **Does not react with water or oxygen** at room temperature.

8.4. LAB GROWN DIAMONDS

Why in the news?

Recently, the Indian Prime Minister during his state visit to the USA gifted a 7.5 carat eco-friendly lab grown diamond to the first lady of the USA.

LGDs	Natural Diamonds
• **No dirt or impurities** ingrained. • **Affordable** even in better quality. • Created with **little to no environmental damage.** • **Guaranteed origins** and **trackable source**	• **Impurities and strains** in crystal structure • Can be **expensive** • Mining natural diamonds causes **water pollution**. • Natural diamonds can **come from conflicted regions.**

Lab Grown Diamonds (LGD's)

- Artificially manufactured diamonds through crystallisation of pure carbon with the same physical and chemical properties as natural diamonds.
- **Used** for **industrial applications** due to their hardness and strength.
- Ideal for **use as cutters and in other tools** and **machines**.
  - In electronics, pure synthetic diamonds are **used as heat spreaders for high-power laser diodes**, laser arrays, and high-power transistors due to their excellent **thermal conductivity.**
- **Methods of Production of LGD**
  - **High Temperature High Pressure (HTHP)** Method **(**Usually graphite is used as the diamond seed)
  - **Chemical Vapour Deposition Method.**
- Government has **eliminated the 5 % tax on LGDs**.

8.5. GIANT MAGNETORESISTANCE

Why in the News?

Recently, Nobel laureate Andre Geim discovered that Graphene displays an anomalous **giant magnetoresistance (GMR)** at room temperature.

About Giant magnetoresistance (GMR)

- GMR is the result of **electrical resistance of a conductor** (sandwiched between two materials) being **affected by magnetic fields in adjacent materials**.
  - **When** materials are **magnetised in same direction**, electrical **resistance in the conductor is low** and vice-versa
- **Application of GMR:** Hard disk drives and magnetoresistive RAM in computers, biosensors, automotive sensors, micro-electromechanical systems, and medical imagers.
- **About Graphene**
  - **Two-dimensional single-atom-thick layer** of **carbon atoms.**
  - Bonded in a **hexagonal honeycomb lattice structure.**
  - **Extracted** from **graphite.**
  - Displays unique **physicochemical properties** like:
    - ✓ High surface area, good biocompatibility, strong mechanical strength, excellent thermal conductivity, and fast electron transportation.
  - **Applications include Energy** (Solar cell, Fuel cell, Super computers etc); **Sensor, Bio-sensor**; **Biomedical** (diagnostic, drug delivery etc.); etc.
  - **India's first Graphene Innovation Centre** has been set up in Kerala.

About Graphite (Plumbago or black lead)

- Naturally occurring form of **crystalline carbon.**
  - **Types:**
    - ✓ **Natural**- High crystalline, Amorphous and Flake
    - ✓ **Synthetic**- Produced from coke and pith
  - **Features:**
    - ✓ **Allotropes** of **carbon**.
    - ✓ **Good conductor** of **heat** and **electricity.**
  - **Applications:** Used in **pencils, lubricants, polishes**, **batteries**, cores of nuclear reactors etc.

8.6. RADIOMETRIC DATING

Why in the News?

A recent study has shown that **Calcium-41** can be used in **radiometric dating** as Carbon-14 with the help of a technique called **Atom-Trap Trace Analysis (ATTA).**

About Calcium-41

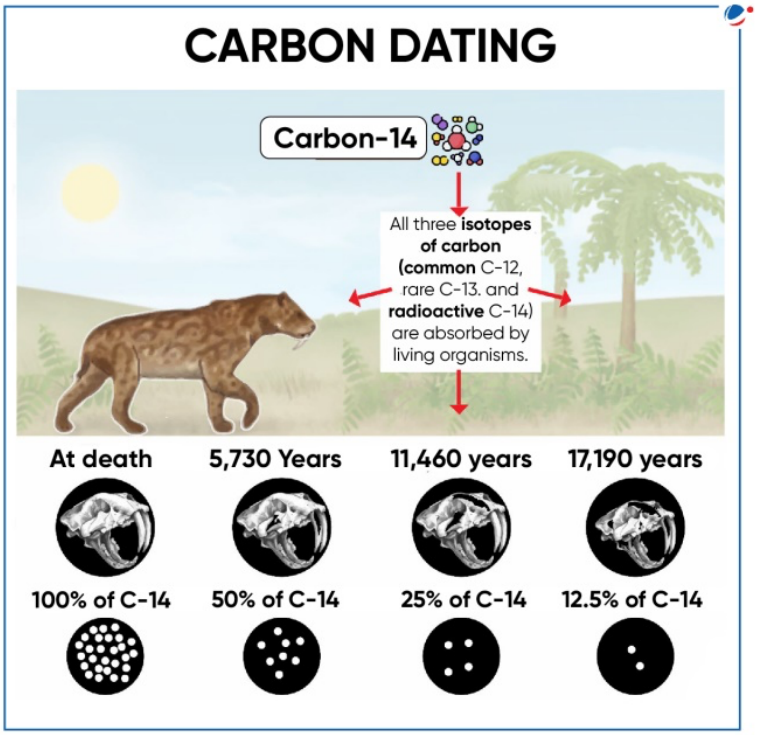
- **Half-life:** Rare long-lived radioisotope of calcium with a half-life of 99,400 years.
- **Availability**: Produced through cosmic ray interactions in the soil and is found in the Earth's crust.
- **Occurrence:** Occurs less frequently than carbon-14.

What is radiometric dating?

- A method of establishing how old something is – perhaps a wooden artefact, a rock, or a fossil – based on **the presence of a radioactive isotope within it. E.g., carbon-14, potassium-14/argon-40.**

Working

- When an organic entity is alive, its **body keeps absorbing and losing carbon-14 atoms.**
- When it dies, this process stops, and the **extant carbon-14 starts to decay away.**
- Using the difference between the **relative abundance of these atoms in the body** and the number that should've been there, researchers can estimate when the entity died.



Limitations with Carbon 14

- **Unstable** and **weak radioactive isotope** of carbon.
- Half-life of 5,700 years.
- Cannot determine the age of objects **older than approximately 50,000 years.**
  - **Most abundant** isotope of carbon in atmosphere is **C-12.** Ratio of C-12 to C-14 in atmosphere is almost static, and is known.
    - ✓ This method **cannot be used to determine age of non-living things** like rocks.

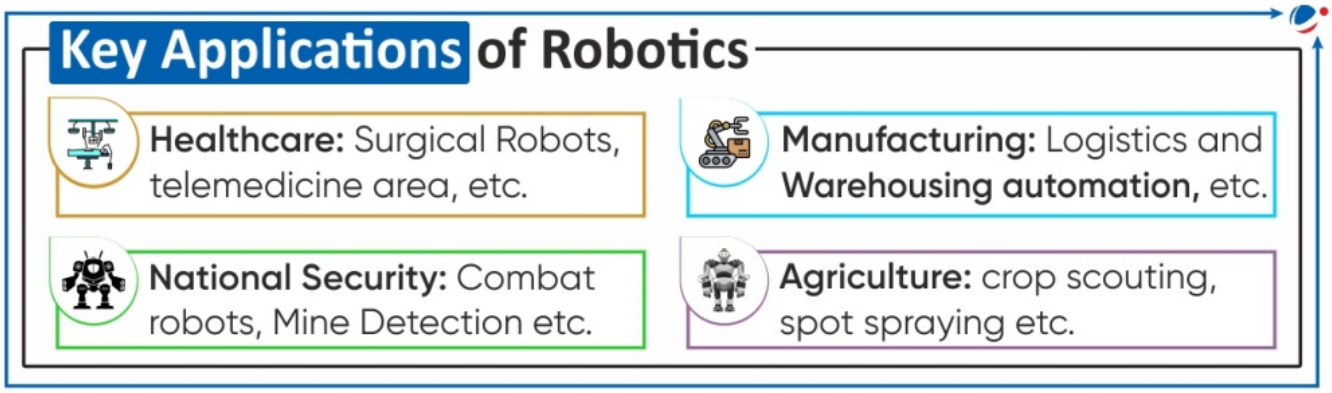
8.7. DRAFT NATIONAL STRATEGY FOR ROBOTICS (NSR)

Why in the News?

Draft **National Strategy for Robotics (NSR)** has been released by the **Ministry of Electronics and Information Technology (MeitY)**.

About Robotic Technology and Strategy

- **Robotic technology** includes **design**, **construction, operation,** and **use of robots**, etc.
- **Classification** of robots as per NSR: **Industrial, Service** and **Medical Robots.**
- MeitY will be the **implementing agency**.
- Telangana has become the **first state in the country** to launch a **state robotics framework.**



Related Development

Robotic Process Automation (RPA) Lab

- MeitY has inaugurated Robotic Process Automation (RPA) Lab.
- **RPA Lab** has been built under **Future Skill PRIME Project,** funded by MeitY.
  - **Future Skill PRIME Project** aims to create an **up-skilling and re-skilling ecosystem** in 10 emerging technologies, such as AI, IOT, blockchain etc.
- **About Robotic Process Automation (RPA)**
  - Also referred as **software robotics**.
  - Uses **intelligent automation technologies to perform repetitive office tasks** of human workers.
  - Combines **Application Programming Interface (APIs) and user interface (UI) interactions** to integrate and perform repetitive tasks.

8.8. HYBRID NANOPARTICLES

Why in the News?

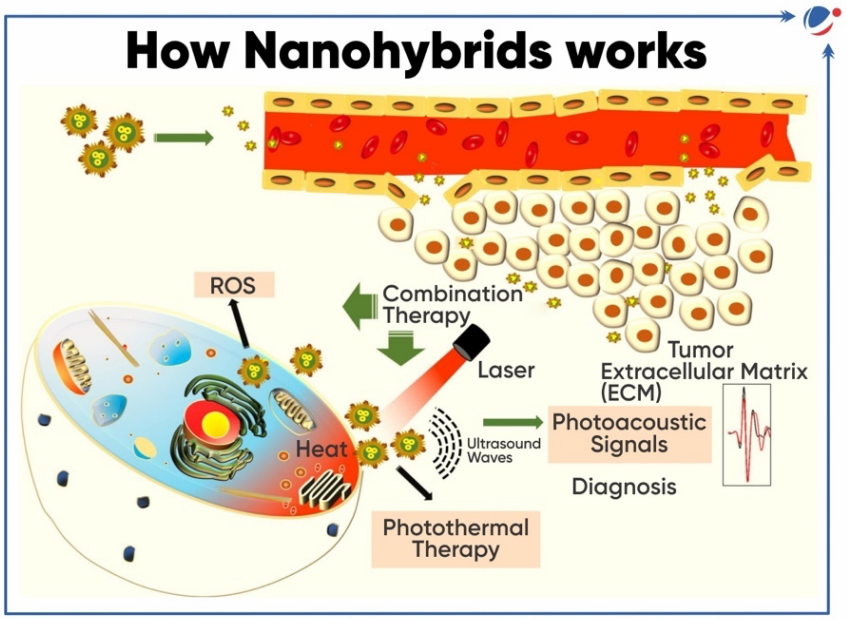
A study used the Hybrid Nanoparticles/ nanohybrids made of gold and copper sulphide, to cure cancer cells using heat, and enable their detection using sound waves.

About Nanohybrids

- A Nanohybrid is **usually of less than 8 nm in size,** are made by combining at least two different nanoparticles.

- Nanoparticles are materials having sizes ranging from 1 to 100 nm (1nm is equal to 10^{-9}m).

Mechanism



- **Diagnosis:** Due to Photo-acoustic properties **they absorb light** and **generate ultrasound waves**.
- **Treatment: Due to Photo-thermal property they produce heat** which kills tumour cells**.**
  - Also produce **reactive oxygen species (ROS)** effects that are toxic to the tumor cells.
- **Nanoparticles can be triggered to produce heat** by shining a **light on them using an endoscope** (typically used for cancer screening) making it a **combination therapy (refer to image).**

8.9. OTHER IMPORTANT NEWS

8.9.1. WHITE PHOSPHORUS

- As per **Human Rights Watch,** Israel fired white phosphorus bombs over Gaza and Lebanon during their conflict with Hamas.
- White phosphorus is a **waxy, yellowish-to-clear chemical with a pungent**, **garlic-like odour**.
  - It is **used by military in form of various types of ammunition as an incendiary agent** because it spontaneously **catches fire in air** when it comes into **contact with oxygen**.
  - **Applications**: Used as a component in **fertilisers, food additives and cleaning compounds**.
  - **Impact of white phosphorous**- severe deep burns, systemic toxicity, coughing, headache etc
- White phosphorus weapons are **not banned**, but their **use in civilian areas is considered a war crime.**
- White phosphorus is **not a chemical weapon under the Chemical Weapons Convention (CWC),** as it acts as an incendiary agent and not through its "chemical action on life processes.

8.9.2. SUPERCRITICAL CARBON DIOXIDE

- Researchers at IIT-Madras found that **supercritical carbon dioxide** is a good agent to **flush out oil** from **depleting oil and gas reservoirs.**
- Supercritical carbon dioxide is a **fluid state of carbon dioxide** where it is held **at** or **above its critical temperature** and **critical pressure.**
- Helps in simultaneous **carbon dioxide sequestration** and **enhanced oil recovery (EOR)** from depleted reservoirs.

8.9.3. TANTALUM

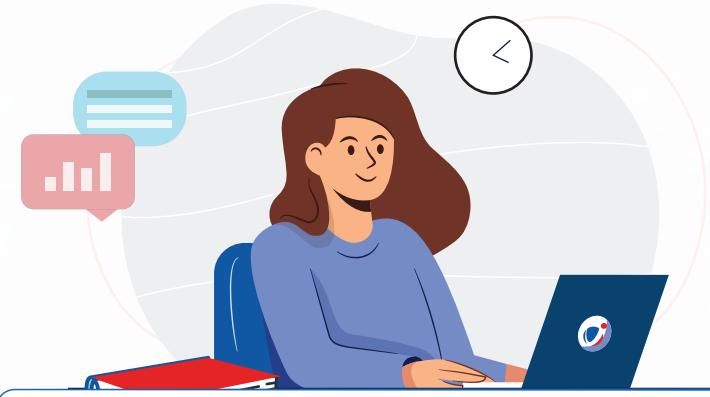
- Researchers found the presence of tantalum in the Sutlej river sand in Punjab.
- **Properties of Tantalum:**
  - **A rare metal**
  - Grey, heavy, **Ductile and very hard metal**.
  - Possesses **high corrosion resistance.**
  - It is almost **completely immune to chemical attacks** at temperatures below 150°C.

- Extremely high **melting point**.

- **Uses of tantalum:**
  - In industries like Electronics and semiconductors, nuclear power plants, aeroplanes, biomedicals etc.
  - Can be used to **Substitute Platinum** due to its high melting point and lower cost.

8.9.4. HYPERLOOP

- **Tata Steel and TuTr Hyperloop** (deep-tech startup operating from IIT Madras) signed a Memorandum of Agreement **to jointly work on development of hyperloop technology**.
- Hyperloop is a **proposed ultra-high-speed (at over 700 miles an hour) ground transportation system** for passenger and cargo.
  - Hyperloop concept has been promoted by Musk and SpaceX, and other companies.
  - It has **three essential elements**:
    - ✓ **Tube** is a large, **sealed low-pressure system or vacuum tubes** (usually a long tunnel).
    - ✓ **Pod is a coach pressurized at atmospheric pressure** that runs substantially free of air resistance or friction inside this tube **using magnetic propulsion.**
    - ✓ **Terminal** handles **pod arrivals and departures.**
- **Benefits:**
  - Offers very fast speed of transportation which is almost twice that of aircraft.
  - Has very low power consumption.
  - Low cost transportation system on long run.(however initial cost maybe high)
  - Immune to bad weather conditions.



Mastering CSAT:

A Strategic Roadmap for UPSC Prelims Examination

The UPSC Prelims is the initial, highly competitive stage of the Civil Services Examination, consisting of two objective-type papers: General Studies and the Civil Services Aptitude Test (CSAT). These papers assess a candidate's knowledge, understanding, and aptitude.

With the CSAT's growing complexity, achieving the 33% qualifying score is challenging. Aspirants must navigate time management, adapting to changing difficulty levels, maintaining balance with General Studies, and finding quality practice materials. This underscores the importance of a well-planned strategy.

Scan QR Code for **Instant Personalized Mentoring**

Strategic Framework for CSAT Preparation

Initial Self-Assessment: Begin with a self-evaluation using the previous year's CSAT papers to identify strengths and areas for improvement.

Study Plan: Develop a structured study plan, focusing on high yielding areas and selecting reliable study sources.

Regular Practice and Post-Test Analysis: Solving and analyzing previous year papers and mock tests to familiarize with the exam format and question types, ensuring a strategic approach to covering the comprehensive syllabus effectively.

Seeking Personalized Mentorship: Engage with mentors to receive customized strategies for improvement. Alongside essential stress management guidance, ensuring a focused and balanced preparation journey.

Reasoning: Sharpen your logical and analytical reasoning by practicing diverse question types from Clocks, Calendars, Series & Progression, Direction, Blood Relation, Coding-Decoding, Syllogism, and so on.

Focus on understanding patterns and building a step-by-step approach to solving problems.

Maths and Basic Numeracy: Strengthen foundational mathematics by revisiting basic concepts and practicing regularly.

Utilize shortcuts and mental math techniques for quicker calculations.

Comprehension: Improve your reading speed and comprehension by regularly reading newspapers.

Practice summarizing paragraphs and infer the main ideas to enhance understanding.

Elevate CSAT preparation with VisionIAS's **CSAT Classroom Program.** This comprehensive course is designed to build fundamental concepts, enhance problem-solving abilities, and foster critical thinking. Featuring offline/online and recorded classes, personalized mentoring, and regular practice through tutorials, it sets you on the path to mastering the CSAT.

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Further refine your preparation with our **All India CSAT Test Series & Mentoring Program,** comprising:

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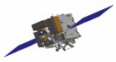
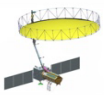
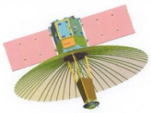
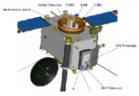
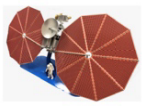
APPENDIX | SPACE MISSIONS AND RELATED DEVELOPMENT

Indian Space Research Organisation (ISRO)

Mission	Salient Features
 **AstroSat (2015)**	» AstroSat has successfully detected its **600th Gamma-ray Burst (GRB).** » **First dedicated Indian astronomy mission.** » **Studies celestial sources in X-ray,** optical and UV spectral bands simultaneously. » Aims to **understand high energy processes** in binary star systems containing neutron stars and black holes, etc.
 **Reusable Launch Vehicle Autonomous Landing Mission (RLV LEX) (2023)**	» Reusable Launch Vehicle Autonomous Landing Mission (RLV LEX) Test was carried under the **Reusable Launch Vehicle Technology Demonstration (RLV-TD) Programme.** » RLV is essentially a space plane with a low lift to drag ratio and can travel to low earth orbits to again payloads and return to earth for use again. » It can be scaled up to become the **first stage of India's reusable two-stage orbital (TSTO) launch vehicle.** » RLV-TD Programme aims at **developing essential** technologies for a **fully reusable launch vehicle** to enable low-cost access to space. » Includes technologies like **hypersonic flight (HEX), autonomous landing (LEX), return flight experiment (REX),** powered cruise flight, and Scramjet Propulsion Experiment (SPEX) » **Advantages: Low-cost, reliable, and on-demand mode of accessing space.**
 **PSLV Orbital Experimental Module-2 (POEM-2)**	» **ISRO carried out** scientific **experiment using POEM-2 in PSLV-C55 mission.** ⇾ **PSLV is a four-stage launch vehicle** (1st & 3rd stage: Solid; 2nd & 4th: Liquid). » **Mission,** for the first time, **saw solar panels powering PSLV's fourth (final) stage.** ⇾ **Usually, fourth and final stage of a rocket** remains in space for only a couple of days before **dropping back into the atmosphere and burning up.** » **However, PSLV includes PSLV Orbital Experimental Module-2 (POEM-2)** platform **to perform in-orbit experiments using the final stage of PSLV.** ⇾ POEM has a **dedicated Navigation Guidance and Control system** which **acts as platform's brain** to stabilize it with specified accuracy. ⇾ POEM will derive its **power from mounted solar panels and a Li-Ion battery.**
 **NASA-ISRO Synthetic Aperture Radar (NISAR) Satellite (2024, planned)**	» **NISAR is a Low Earth Orbit (LEO)** observatory. » Aims to map the entire globe in 12 days. » **Developed along with NASA.** » **Significance:** Large imaging area (>240km) and High precision and resolution (<1cm). » **Applications:** Ecosystem and Resource Tracking, Disaster Management, cryoshpere tracking.
 **PSLV-C56**	» Recent launch of PSLV-C56 conducted the **fourth stage (PS4) de-orbiting experiment.** » **De-orbiting of satellites is a** technology to drag satellites to the graveyard orbit, i.e., orbit 200 miles farther away from Earth than the farthest active satellites.). ⇾ **De-orbiting systems can be passive** (use of integrated spacecraft) **and active systems** (designed to move satellites in the graveyard orbit. » **De-orbiting experiment** result in reduced space debris and sustainable use of space.

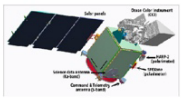
APPENDIX | SPACE MISSIONS AND RELATED DEVELOPMENT

National Aeronautics and Space Administration (NASA)

Mission	Salient Features
 Mars 2020	» Perseverance rover **found diverse organic matter on Mars.** ⊖ Part of Mars 2020 Mission. » **Scanning Habitable Environments with Raman and Luminescence for Organics and Chemicals (SHERLOC) instrument** on rover detected **organic molecules in Jezero Crater.** ⊖ **SHERLOC** uses **ultraviolet laser light to search for organics and minerals.** ◆ **SHERLOC also uses Raman spectroscopy.** » **Only the Mars Phoenix lander and Curiosity rover** have been able to **detect organic carbon.** » It consists of **Mars Oxygen In-Situ Resource Utilization Experiment (MOXIE).**
 STEREO-A Spacecraft	» **Solar Terrestrial Relations Observatory (STEREO-A) Spacecraft** passed between Sun and Earth. » Marks the **first Earth flyby of nearly 17-year-old mission.** » STEREO **traces the flow of energy and matter from Sun to Earth.**
 Tropospheric Emissions Monitoring of Pollution (TEMPO) Satellite	» TEMPO satellite monitors air pollution hourly over North America. » TEMPO is **NASA's first Earth-observation satellite in geostationary orbit.** ⊖ It allows scientists to **monitor air pollutants and their emission sources from space** more comprehensively than ever before.
 Integral Field Ultraviolet Spectroscope Experiment (INFUSE) mission	» INFUSE Mission aims to **spectroscopically image** a region of **Cygnus Loop,** studying shock fronts as material from the supernova interacts with interstellar medium. » **Cygnus Loop** is the **remnant of a star** that was once 20 times the size of our Sun. » Will be the **first far ultraviolet integral field spectrograph (IFS)** in space and will have access to the Lyman ultraviolet.
 Voyager 2	» NASA detected signal from Voyager 2 Mission. » Only spacecraft to study **all four of the solar system's** (Jupiter, Saturn, Uranus, and Neptune) giant planets at close range.
 Lucy Mission	» NASA's Lucy mission has discovered that the **asteroid Dinkinesh is actually a binary system of two asteroids.** » Launched in 2021, Lucy is the **first space mission to explore Jupiter Trojan asteroids.** ⊖ Trojans are a **group of small bodies** (remnants of early solar system) **that orbit the Sun** in two "swarms" along the orbit of Jupiter.

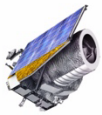
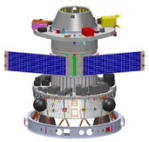
Prominent Mars Missions

Country	Missions
India	Mangalyaan
USA	Mars Reconnaissance Orbiter and Mars Odyssey
China	Tianwen-1
Europe (European Space Agency)	Mars Express
United Arab Emirates (UAE)	Hope

 **Exobiology Extant Life Surveyor (EELS)**	**NASA** is testing **EELS,** a **futuristic** Snake shaped robot. ⊙ **Versatile robot** that would **autonomously map, traverse,** and **explore** previously **inaccessible destinations** ⊙ Capable of **making decisions on its own** in uncertain and unknown environments. ⊙ Creates a **3D map** of its surroundings using **stereo cameras and Lidar (Light Detection and Ranging).**
 **PACE Mission**	NASA is **preparing** to launch **'Plankton, Aerosol, Cloud, and Ocean Ecosystem' (PACE) mission** in 2024. Mission **will provide a combination of global atmospheric** and **oceanic observations.** ⊙ **By monitoring aerosols in the atmosphere along with plankton on the surface of the ocean,** scientists can collect information about the health of the Earth.

APPENDIX
SPACE MISSIONS AND RELATED DEVELOPMENT

Other Space Agencies

Mission	Salient Features
 **Euclid Mission**	• **Launched by:** European Space Agency • **ESA's (European Space Agency) Euclid mission** lifted off. • Euclid aims to **investigate cosmic mysteries of dark matter and dark energy.** It will make a **3D map of the Universe** by observing billions of galaxies. • Euclid has **a reflecting telescope** that feeds the two instruments: a **visible wavelength camera** (VIS) and Near-Infrared Spectrometer and Photometer (NISP). ⊖ It will travel towards Sun-Earth Lagrange point 2.
 **Cassini Mission**	• **Launched by: Joint endeavor of NASA, ESA** (European Space Agency), and **Italian space agency** (ASI). • **Cassini spacecraft** has found **phosphorus in water geysers of Enceladus** ⊖ **Phosphorous is considered as the building block of DNA.** • **Enceladus** is the second nearest of major regular moons and **the brightest of all moons of Saturn.** • **It is an icy moon,** which harbours enormous ocean of liquid water beneath its crust. • **Cassini mission was designed to explore the Saturn system,** including its rings and moons, with a special focus on Titan.
 **SOFIA (Stratospheric Observatory for Infrared Astronomy)**	• **Launched by:** NASA and German Aerospace Center • Scientists have detected **atomic oxygen in the atmosphere of Venus through SOFIA airborne observatory.** • SOFIA is the world's largest **airborne astronomical observatory** (joint program of **NASA and German Aerospace Center).** ⊖ It flies in the **stratosphere,** above 99% of Earth's infrared-blocking atmosphere to **observe the infrared universe.**
 **Tiangong Space Station**	• **Launched by:** China. • **China launched Shenzhou-16 spacecraft,** carrying three astronauts, **including its first civilian, to its Tiangong space station.** • Tiangong space station, or Heavenly Palace, is **China's new permanent space station.**

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UPSC TOPPERS PREPARATION APPROACH & STRATEGIES

Insights from Toppers' Talk and Answer Scripts

Ishita Kishore

Rank 1, 2022

Ishita Kishore, the UPSC topper of 2022, serves as a remarkable inspiration for her unwavering determination and relentless efforts making her as a beacon of motivation for aspiring candidates. Through her methodical preparation approach, she emerged triumphant in the esteemed Civil Services Examination securing top rank. Ishita extensively relied on VisionIAS Mains test series to refine her answer writing abilities. To gain further insights into Ishita's answer writing approaches, kindly scan the QR code provided.

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UPSC CSE TOPPERS 2022

Waseem Ahmad Bhat

7 RANK 2022

Waseem Ahmad Bhat, an exceptional achiever who secured an All India Rank 7 in his third attempt in the UPSC Civil Services Examination 2022. He also achieved All India Rank 225 in his first attempt in 2020 and currently, he is training as an Assistant Commissioner Income Tax.

Waseem was a student of the **VisionIAS Foundation Course**, Batch in 2019.

Hailing from Doru Shahabad, Anantnag, Jammu & Kashmir, he completed his schooling in Anantnag and holds a degree in Civil Engineering from NIT Srinagar.

Waseem opted for **Anthropology** as his optional subject. His topper's talk covers vital topics such as preparing for the **changing pattern of Prelims**, essay writing and strategy, writing **quote-based essays,** utilizing topper's answer scripts for preparation, and **effective revision strategies.**

TOPPERS' TALK

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Aniruddh Yadav

8 RANK 2022

Aniruddh Yadav, a remarkable achiever who secured an All India Rank 8 in his fourth attempt in the UPSC Civil Services Examination of 2022.

Aniruddh opted for **Anthropology** as his optional subject. He completed his dual degree course in Biochemical Engineering & Biotechnology from IIT Delhi.

His topper's talk covers crucial aspects such as **creating a schedule** and **subject-wise timetable,** honing answer writing skills through topic-based **practice, mastering the structure** and format of answers (Introduction, Body, Conclusion), **managing time effectively** during answer writing practice, and preparing **topic-wise notes** with the help of syllabus analysis and previous year questions.

TOPPERS' TALK

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Siddharth Shukla

18 RANK 2022

Siddharth Shukla, belongs to Uttar Pradesh. He completed his BA in History (H) from Delhi University, which was also his optional subject.

He displayed exemplary resilience by appearing in the exam for the fourth attempt and secured AIR 18 in 2022.

The preparation strategy reflected in his talk and answer scripts include the strategy for Essay, **efficient use of PYQs, notes making,** among others.

Additionally, he has also focused upon **non-academic aspects** such as **stress management, habit formation, and role of meditation** which are critical for this examination.

TOPPERS' TALK

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Anoushka Sharma

20 RANK 2022

Anouska Sharma hailing from Madhya Pradesh completed her graduation from City University, New York with a bachelor's degree in Economics. She gained job experience through a three-month internship with the United Nations prior to taking the civil service examination.

She passed her CSE with AIR 20 in 2022 on her third attempt. **Economics** is her optional subject.

She has a very good command over ethics paper and she has shared her **insights on time management and strategy for attempting questions** in CSE Mains.

TOPPERS' TALK

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UPSC CSE TOPPERS 2021

Gamini Singla

3 RANK 2021

Gamini Singla, hailing from Punjab, completed her graduation in Computer Science Engineering from Punjab Engineering College Chandigarh. Thereafter, she honed her skills through a five-month internship as a finance analyst at JP Morgan.

She secured a remarkable All India Rank of 3 in the UPSC CSE 2021 in her second attempt with **Sociology** as her optional subject.

With her strategic **approach to GS Paper IV (Ethics) and Essay,** Gamini demonstrated her ability to **critically analyze ethical issues** and effectively express her thoughts in a coherent manner.

Her expertise in answer writing provided her with a competitive edge, allowing her to convey her knowledge and insights concisely.

TOPPERS' TALK

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Aishwarya Verma

4 RANK 2021

Aishwarya Verma hails from Madhya Pradesh. After graduating in Electrical Engineering, he opted for Civil Services as a career of choice.

He chose **Geography** as his optional subject and achieved an All-India Rank 4 in UPSC CSE 2021 in his fourth attempt.

Apart from the hard work, determination and resilience shown by Aishwarya, his success can also be attributed to his **short and enriched self-made notes, advanced answer writing skills**, and smart preparation strategy, including S&T.

TOPPERS' TALK

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Utkarsh Dwivedi

5 RANK 2021

Utkarsh Dwivedi, hailing from historic town of Ayodhya, Uttar Pradesh, a graduate in Mechanical Engineering from VIT Vellore, displayed resilience by attempting the exam for the third time and succeeding with remarkable achievement with the optional subject, **Political Science and International Relations.**

He displayed **exemplary command over Ethics Paper**, specially Case Studies and **quotation-based questions.** With his deep understanding of the demand of the UPSC Examination and excellent time management skills, he not only optimized his efforts, but also maximized his performance at all stages of the UPSC CSE.

TOPPERS' TALK

TOPPER'S COPIES

Yaksh Chaudhary

6 RANK 2021

Yaksh Chaudhary, a resident of Amroha, Uttar Pradesh, through unwavering determination secured an All India Rank 6 in the prestigious exam on his third attempt in 2021. With his passion for Sociology, Yaksh opted for it as his optional subject and devised a winning strategy for his preparation.

Yaksh's **exceptional expertise in answer writing** and adeptness in attempting question papers during the mains exam provided him an edge. Moreover, his skill in crafting **well-structured diagrams** for General Studies, Ethics, and Sociology further enriched the quality and visual appeal of his responses. Yaksh's achievements serve as an inspiration to aspiring candidates nationwide, exemplifying the significance of perseverance, dedication, and strategic planning.

TOPPERS' TALK

TOPPER'S COPIES

UPSC CSE TOPPERS 2020

Shubham Kumar

1 RANK 2020

Shubham Kumar, hailing from Katihar District in Bihar, completed his graduation in Civil Engineering from IIT Bombay. He achieved the remarkable feat of securing All India Rank 1 in the UPSC examination of 2020 in his third attempt.

His success can be attributed to his **unique approach and meticulous preparation.** Shubham emphasized the importance of **regular mock tests** for prelims and carefully analyzing previous years' UPSC prelims questions.

Shubham was a student of the **VisionIAS Foundation Course.**

He also **utilized topper's copies to enhance his skills in ethics answer writing** and emphasized the **use of diagrams and graphs** in GS papers.

TOPPERS' TALK

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Jagrati Awasthi

2 RANK 2020

Jagrati Awasthi, from Bhopal, Madhya Pradesh, completed her graduation in Electrical Engineering from NIT Bhopal. She gained two years of valuable work experience at BHEL.

With **Sociology** as her optional subject, she achieved an outstanding All India Rank of 2 in the UPSC examination of 2020.

She has emphasized the **importance of a well-structured daily routine** and shared a **detailed booklist** and recommended sources. Jagrati stressed the significance of thorough reading and utilizing previous years' questions to grasp the exam's demands.

Along with refined **note-making techniques,** she has provided insights on determining the optimal number of questions to attempt in the prelims and leveraging previous year's question papers for **Ethics case studies'** preparation.

TOPPERS' TALK

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Praveen Kumar

7 RANK 2020

Praveen Kumar, achieved an impressive All India Rank 07 in the UPSC Civil Services Examination 2020. Hailing from Jammui, Bihar, Praveen holds a degree in Civil Engineering from IIT Kanpur.

His remarkable journey includes clearing the GATE examination with an AIR 5 and securing AIR 3 in the Indian Engineering Services (IES) exam, all while working for the Indian Railway Service.

Praveen's toppers talk provides invaluable insights, covering motivations for pursuing the IAS, **effective booklists and sources for exam preparation, strategies for newspaper reading and content extraction, note-making techniques** for mains, and **utilizing flow charts and diagrams** in answers.

TOPPERS' TALK

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Satyam Gandhi

10 RANK 2020

Satyam Gandhi, an exceptional achiever, secured an All India Rank 10 in the UPSC Civil Services Examination 2020. Hailing from Bihar, Satyam graduated in Political Sciences (H) from Dayal Singh College, University of Delhi.

With **Political Science and International** Relations as his optional subject, he cleared the exam on his first attempt, displaying remarkable determination.

In addition, Satyam achieved an impressive AIR 242 in the NDA Exam. His toppers talk offers invaluable insights into **time management strategies** for a first attempt success, the **significance of flowcharts and diagrams** in mains answers, **effective essay structuring**, and his experience in obtaining a remarkable 201 marks in the interview.

TOPPERS' TALK

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VISAKHAPATNAM | WARANGAL

Heartiest Congratulations
to all Successful Candidates

39 in Top 50 Selections in CSE 2022

Ishita Kishore

Garima Lohia

Uma Harathi N

8 in Top 10 Selections in CSE 2021

ANKITA AGARWAL

GAMINI SINGLA

AISHWARYA VERMA

UTKARSH DWIVEDI

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